NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. XIX. June, 1905. No. 2.

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THE MAINE WATER DISTRICTS AND APPRAISALS.

BY HARVEY D. EATON, WATERVILLE, ME.

[*Read February 8, 1905.*]

I hardly need say, for this audience will speedily discover it for themselves, that I am not a practical water-works man.

My regular calling is the law. But problems connected with water works have engaged my attention almost constantly for nearly ten years, and this Association has done me the honor to admit me to its membership.

I fully realize that discussions of municipal ownership are nearly twenty years behind the times, but, while I yield to no one in pride in my native state, I am obliged to confess that it is only recently that municipal ownership became generally practicable in our state.

More than thirty years ago excessive indulgence in municipal aid to railroad enterprises led to the adoption of a constitutional debt limit of five per cent., with no exceptions in favor of water debts. At that time there were few water plants in the state, and as others came to be installed by private parties the owners found this municipal debt limit a safe barrier against disturbance of their investments. The leading water-works owners were also leading railroad men, and as our principal railroads are part and parcel of the Boston & Maine system, the whole combination of railroad lawyers and lobbyists of Maine and Massachusetts was constantly arrayed against all efforts at municipal ownership.

At one time, ten or twelve years ago, a noteworthy attempt was made to change the constitution so that water debts would be excepted from its operation. The owners of water systems, through their friends and agents, worked up a perfect scare among the saving banks of the state, each one of which held a few water company bonds, so that they remonstrated and protested with the utmost vigor against the change, and the legislature was induced not to submit the matter to the people at all. The attempt has never been renewed, and our debt limit still remains unchanged.

Living in Waterville, my interest was engaged in local conditions in 1895. Two or three years of otherwise fruitless contention over minor matters revealed to the community that we were paying exorbitant rates for wretched water service. Besides our own city, three adjoining villages were supplied from the same station and reservoir, making a very remunerative plant for the owners, while the water was taken from a small stream which served as the outlet for the sewers of another village only five miles away. This same stream also furnished power for pumping. Spring water wagons made daily rounds and the expense of water from that source in many families equaled the amount paid the public water company. The fact that within a radius of ten miles were eight splendid ponds only added to the aggravation. The owners of the plant lived at a distance, and the returns made them satisfied.

Our own city's debt was at the limit, and the proposition was too large for the other places. After wasting months of study on impracticable plans, it occurred to me that if all the places served should unite to form a new municipality for water purposes only, it would not be subject to the debt limit which by the language of the constitution applied expressly to cities and towns. Months more were spent in drafting and revising a bill to embody this idea, and in March, 1898, I submitted it to my former instructor in constitutional law, Prof. James B. Thayer, of the Harvard Law School. In a very kind note he stated his belief that the plan was legal and encouraged me to present it to the public.

The rest of that year was spent in holding meetings and conferences in the four places. Finally, only one place, the Fair-

field Village Corporation, decided to join with our city in asking for the proposed legislation.

The bill was introduced in January, 1899, and passed with no opposition.* In fact, up to this time the water company had seemed to regard the whole matter as a harmless vagary. It was provided that the act should not take effect unless approved by a popular vote in each of the places composing the district. Apparently the company assumed that the bill would fail of popular approval, but it was ratified by overwhelming votes in each place.

Proceedings under the act were begun at once, and then we learned that the day of gentle tolerance was past. The list of counsel who appeared against that process included about all the distinguished corporation attorneys in the state. Every pretext for delay, and every objection that human ingenuity could devise, were interposed. At length the various questions as to the legality of the act, and the right to proceed under it, were argued before the full bench in Portland on successive days in August, 1900.

In March, 1902, the court published its opinion, which was lengthy and sweeping. The act was completely sustained. Its constitutionality and the legality of all its provisions were upheld. And thus there came into operation in the state of Maine a practical plan of municipal ownership where formerly the private corporation had held almost unbroken sway. Bangor and Lewiston, to be sure, already had city ownership of their water plants, but they began many years ago, and the other cities and towns found it impossible to follow their lead on account of the debt limit.

The Kennebec Water District, the pioneer, included Waterville and Fairfield, but was also authorized to serve the two adjoining towns of Benton and Winslow, being the territory already served by the Maine Water Company.

The plan has been adopted at Dover and Foxcroft, Augusta, Gardiner, and Brunswick, while many other places are watching its operations and discussing the subject of its adoption for themselves.

* The act is abstracted in Appendix I.

The plan is nothing more than the organization of the desired territory and people into a new, distinct, and separate municipality for water purposes only, leaving all other forms of municipal government to pursue their accustomed functions precisely as though the district had not been organized.

The whole charter contains only sixteen brief sections covering about six octavo pages.

The act provided that the district might acquire by exercise of the right of eminent domain "the entire plant, property, and franchises, rights, and privileges" held by the water company within the district and the two adjoining towns, and that the court should appoint a board of three appraisers to "fix the valuation of said plant, property, and franchises at what they are fairly and equitably worth, so that said Maine Water Company shall receive just compensation for all the same."

This provision made a radical distinction between our appraisal and those with which the country has generally become familiar, in that it allowed the appraisal of the franchise.

The inclusion of the franchise with the property to be appraised is the rule, but the exceptions are much more numerous than the cases where the rule is followed.

For instance, in the Kansas City case, which is one of the best-known authorities in this country, it was expressly provided by contract before the works were built that after a certain time they should pass to the city at an appraisal *excluding* the franchise or value arising from future earning capacity. The cases of that class are quite numerous and, of course, there can be no just complaint at the omission of the franchise from the valuation.

In Massachusetts we have another class of cases, of which that at Newburyport is the leading example, where the legislature grants a municipality the right to build a competing system, unless the water company will sell out at a valuation which excludes the franchise.

This procedure is legal, and, theoretically, it is just and fair because as explained by the Federal Circuit Court "it may well be presumed that when a franchise is obtained which is not exclusive, it is taken with the knowledge and risk that the legislature

is not precluded from granting at any moment a similar and competing franchise."

Practically these last-named cases arouse the most bitter controversy, and it is probably true that the builders seldom realized the full meaning of the doctrine that a competing franchise might be granted at any time.

The Waterville case, however, fell in neither of these classes, but was a plain case of appraisal of all the property and franchises.

Our act contained one provision in regard to appraisal that was unique, and proved highly important. It was the following:

"Before a commission is issued to the appraisers, either party may ask for instructions to the appraisers, and all questions of law arising upon said requests for instructions . . . may be reported to the law court for determination before the appraisers proceed to fix the valuation of the property."

Under this provision, after the determination by the court that the district was legally constituted, each party presented numerous and comprehensive requests for instructions, covering every phase of the appraisal that could be foreseen. The court made some caustic remarks about the anomalous character of this procedure, and then considered all the requests of both parties in an opinion which has already taken rank as one of the most important and exhaustive discussions of the general subject of appraisal that has ever been delivered by any court in the world.

That opinion was received December 27, 1902, and on the 6th of October, 1903, the hearing on appraisal began at Waterville before a board agreed on by the parties, and commissioned by the court, consisting of Hon. Frederick A. Powers, a justice of the Supreme Court; Hon. Frederick H. Appleton, a prominent attorney; and Percy M. Blake, Esq., a civil and hydraulic engineer. Careful preparation had been made by both parties, and the hearing proceeded continuously, two sessions a day being held, until the close on October 30. Within a few days afterward the appraisers made their award, fixing the value at $503 437.75.

The award was large, but that was expected, and the district at once accepted it without formal objection of any kind. The amount of the award was subsequently paid over, and thus terminated the long contest in which not only had municipal owner-

ship been accomplished for our own community, but a principle had been established through which the same thing could be accomplished by any community in the state desirous of doing so.

And, of course, you can understand that this has meant very much to me personally. The years of contest with the brightest minds in New England over the legal questions involved was splendid professional training.

And to sit at the feet of such men as William R. Hill, John R. Freeman, Freeman C. Coffin, George C. Whipple, and John W. Alvord, not to mention such younger men as Dr. E. C. Levy and Leonard Metcalf, and study and discuss with them the problems of hydraulics and health, of engineering and construction, of finance and public policy, was a liberal education in itself. And then to be concerned in taking over the works, and have a hand in their operation and management, in the construction of a new supply system, and the reconstruction of the distribution system has still further impressed me with the importance, yes, the true greatness, of this subject to which you gentlemen are devoting your lives.

APPENDIX I.

An Act to Incorporate the Kennebec Water District (Abstract).

The Act is Chapter 200 of the Private and Special Laws of Maine for 1899.

Section 1 is as follows:

"The territory and people constituting the city of Waterville and the Fairfield Village Corporation shall constitute a body politic and corporate, under the name of the Kennebec Water District, for the purpose of supplying the inhabitants of said district and of the towns of Benton and Winslow and all said municipalities with pure water for domestic and municipal purposes."

Sections 2, 3, and 4 confer power to take and distribute water, lay pipe, etc.

Section 5 provides for organization, election of officers, etc.

Sections 6, 7, 8, and 9 give the right to condemn the old company's plant, and provide for judicial appraisal thereof by bill in equity in the Supreme Court.

Section 10 grants authority to issue bonds.

Section 11 provides that water rates shall be uniform, and so established as to provide revenue for current expenses, maintenance, extensions, renewals, interest, and sinking fund.

Section 12 exempts the district's property from taxation.

Section 13 grants all necessary incidental powers, rights, and privileges.

Sections 14, 15, and 16 cover minor details.

An amendment passed in 1905 broadens the financial powers of the district, and provides more specifically for the appraisal of damages in cases where land has been taken or pipes laid.

Separate acts in Maine and Massachusetts have modified the general laws of those states so as to include water district obligations in the list of investments eligible for savings banks.

APPENDIX II.

The first decision of the court, dated March 3, 1902 (96 Me. 234; 52 Atl. Rep. 774), deals with five leading propositions of the defense.

The first asserts the right of the people to take the property and franchises of a corporation already engaged in public service.

This proposition had already been well established by many decisions, several of them being by the United States Supreme Court, but it was stubbornly fought over in this case.

The second and third decide that it is constitutional to have the value of the water company's property fixed by a board of appraisers or commissioners without having it passed upon by a jury, although the act further provides that in settling ordinary claims for damages by reason of laying pipe across private land, etc., the damages shall be assessed by a jury, and that the establishment of these two different modes of assessing damages under the act is not a denial to the water company of "the equal protection of the laws."

The fourth contention was that the taking of the water company's property would result in the impairment of its contracts for supplying water to the various municipalities served. This objection was probably not much relied on, and the court made short work of it, saying, "A contract is property and, like any other property, may be taken under condemnation proceedings for public use."

The fifth and most important proposition dealt with the debt limit. It was admitted that the city of Waterville, a large part of the district, was already in debt to its limit. But the court held that the constitutional limitation by its express language applied only to "cities and towns," and that it was within the province of the legislature to establish other municipal corporations comprising territory already organized into cities and towns, and that these new municipalities would not be governed by the debt limitation nor their powers affected by the fact that the cities and towns of which they were composed were already in debt to the limit. In other words, the new corporation is an entirely free and independent municipality. This is in accordance with established principles of constitutional interpretation, but the application of these principles to our situation in Maine had not before been made.

APPENDIX III.

Kennebec Water District *v.* City of Waterville, and others. Kennebec. Opinion, December 27, 1902.*

* 97 Me. 185; 54 Atl. Rep. 6; 60 L. R. A. 856.

(*Head Notes by the Court.*)

An act incorporating the plaintiff district authorized it to acquire, by the exercise of the right of eminent domain, "the entire plant, property, and franchises, rights, and privileges now held by the Maine Water Company within said district and the towns of Benton and Winslow." The act further provides that appraisers appointed by the court "shall, upon hearing, fix the valuation of said plant, property, and franchises at what they are fairly and equitably worth, so that said Maine Water Company shall receive just compensation for all the same," but that "before a commission is issued to the appraisers, either party may ask for instructions to the appraisers." Both parties having asked for instructions, and the questions of law arising thereon having been reported to the law court, the court is of opinion that the appraisers should be instructed in accordance with the following principles:

1. The plaintiff, if it takes anything, must take all the property held by the Maine Water Company in the Kennebec Water District, and in Benton and Winslow, whether specifically named in the act or not. This includes the real estate or other property, if any, not connected with the water system, it includes the plant or physical system, and it includes all franchises, rights, and privileges held by the water company, exercised or capable of being exercised.

2. The Maine Water Company is a quasi-public or public service corporation, and is entitled to charge reasonable rates for its services, and no more.

3. The basis of all calculations as to the reasonableness of rates to be charged by a public service corporation is the fair value of the property used by it for the convenience of the public.

4. At the same time, the public have the right to demand that the rates shall be no higher than the services are worth to them, not in the aggregate, but as individuals.

5. Summarized, these elemental principles are, the right of the company to derive a fair income based upon the fair value of the property at the time it is being used for the public, taking into account the cost of maintenance or depreciation and current operating expenses, and the right of the public to have no more exacted than the services in themselves are worth.

6. The reasonableness of the rate may also be affected, for a time, by the degree of hazard to which the original enterprise was naturally subjected; that is, such hazard only as may have been justly contemplated by those who made the original investment, but not unforeseen or emergent risks. And such allowance may be made as is demanded by an ample and fair public policy. If allowance be sought on account of this element, it would be permissible at the same time to inquire to what extent the company has already received income at rates in excess of what would otherwise be reasonable, and thus has already received compensation for this hazard.

7. The franchises granted to the Waterville Water Company by Chapter 141, Private and Special Laws of 1881, as amended by Chapter 59, Private and Special Laws of 1887, and Chapter 14, Private and Special Laws of 1891,

and to the Maine Water Company by Chapter 352, Private and Special Laws of 1893, are not exclusive. Neither are they perpetual and irrevocable. They are subject to legislative repeal. In fixing the value of the franchises, both of these considerations are entitled to their just weight. If the business of the company is now practically exclusive, in that it has no competitor, that fact also may and should be considered by the appraisers when they fix the value of the property of the company as a going concern.

8. In determining the present value of the company's plant, the actual construction cost thereof, with proper allowances for depreciation, is legal and competent evidence, but it is not conclusive, nor controlling.

9. The request that "under no circumstances can the value of the plant be held to exceed the cost of producing at the present time a plant of equal capacity and modern design" should not be given. Among other things, it leaves out of account the fact that it is the plant of a going concern, and seeks to substitute one of the elements of value for the measure of value itself.

10. The actual rates which may have been charged heretofore, and the actual earnings are both admissible and material in determining the value of the plant. The value of the evidence, however, will depend upon whether the appraisers shall find that the rates charged have been reasonable.

11. The quality of water furnished and of the service rendered, and the fitness of the plant and of the source of water supply to meet reasonable requirements in the present and future are material upon the question of present value.

12. The appraisers should regard the franchises of the company as entitling it to continue business as a going concern, but subject to all proper legal duties governing public service companies.

13. Faithfulness or unfaithfulness shown by the water company in the past in the performance of public duty to furnish pure water at reasonable rates is not a proper matter for consideration. It is the franchise as it now exists which is to be taken and paid for.

14. The liability of the company to legal forfeiture of its franchises on account of past unfaithfulness and misbehavior is not to be considered.

15. If the water company and its predecessors have actually received more than reasonable rates hitherto, the excess cannot be deducted from the amount to which the company would otherwise be entitled.

16. No compensation can be allowed to the Maine Water Company for incidental damages to its other property having no physical connection with or contiguity to that taken, and having no relations with it except those which grow out of common ownership, nor for the impairment of the economy and efficiency of administration which are obtained by the combination of many water systems under one management.

17. The real estate or other outside property not directly connected with the water system should be appraised at its fair market value, not at forced sale, but at what it is fairly worth to the seller, under considerations permitting a prudent and beneficial sale thereof.

18. The appraisers may properly consider what the existing system can be reproduced for. But the cost of reproduction will not be conclusive. It will be evidence having some tendency to prove present value. The inquiry along the line of reproduction should be limited to the replacing of the present system by one substantially like it.

19. In estimating even the structure value of the plant, allowance should be made for the fact, if proved, that the company's water system is a going concern with a profitable business established, and with a present income assured and now being earned.

20. So far as the water system is practically exclusive, the element of good-will should not be considered.

21. In fixing structure value, while considering the fact that the system is a going concern, the appraisers should also consider, among other things, the present efficiency of the system, the length of time necessary to construct the same *de novo*, and the time and cost needed after construction to develop such new system to the level of the present one in respect to business and income, and the added net income and profits, if any, which by its acquirement would accrue to a purchaser during the time required for such new construction, and for such development of business and income. But these are to be considered "among other things." They are not controlling. Their weight and value must depend upon the varying circumstances of each particular case.

22. In addition to structure-values, the appraisers should allow just compensation for all the franchises, rights, and privileges to be taken.

23. The value of the franchise depends upon its net earning power, present and prospective, developed and capable of development, at reasonable rates; and the value to be assessed is the value to the seller, and not to the buyer.

24. In considering prospective development of the use of a franchise, consideration must also be had of the fact that further investment may be necessary to develop the use, and of the further fact that at any stage of development the owner of the franchise will be entitled to charge only reasonable rates under the conditions then existing.

25. Subject to all the foregoing limitations, the owner is entitled to any appreciation due to natural causes.

26. The fact that the franchises are to be taken in no respect impairs their value for the purposes of appraisal.

27. The property to be taken, both plant and franchises are to be appraised having in view their value as property in itself and their value as a source of income. There are these elements of value, but only one value of one entire property is to be appraised in the end. These elements necessarily shade into each other.

28. The capitalization of income even at reasonable rates cannot be adopted as a sufficient or satisfactory test of present value. But while not a test, present and probable future earnings at reasonable rates are properly to be considered in determining the present value of the system.

29. The appraisers should be instructed to receive and consider all evidence offered, so far as admissible under the general rules of law, which is pertinent under the rules stated in the requests of the parties, so far as they have been approved, and as limited or explained, in the opinion of the court. See S. C. 96 Maine, 234.

DISCUSSION.

MR. J. O. HALL. I should like to ask how that $503 000 was provided for. Was it all furnished by Waterville and then divided; and if so, in what way?

MR. EATON. The city of Waterville and the Fairfield Village Corporation make a new municipality, and that municipality, with an independent organization for water purposes only, raised the money by its own operations. The money was all procured here in Boston, on the district's obligations.

I might say that in considering the subject since the establishment of the district, one needs to drop " Waterville " and " Fairfield "; the Kennebec Water District is its name for all of these questions.

MR. HALL. What effect have all these things had on the rate of taxation in Waterville?

MR. EATON. Not any effect whatever. The expenses of the district are paid from the water rates or the issue of bonds. There is no connection whatever between the district's organization and the cities or towns composing the district, except that in case we have a surplus, — which we hope will happen some day, but which has not occurred yet, — that surplus is to be returned to the cities and towns composing the district, in the proportions in which they contributed to the revenue.

MR. FREEMAN C. COFFIN. I have been very much interested in this paper of Mr. Eaton's, and I was very much interested in the proceedings which led to placing the value on these works. You all see how young a man Mr. Eaton is, or looks to be, and yet I first heard of him as " the father of the Maine Water District Bill." (Laughter.)

We find some differences between what might be called the feeling or the sentiment in Maine towards these questions and that in Massachusetts. I think that a water-works system in Maine is regarded more as a strictly private business than in

Massachusetts. It seems to be the feeling there that these companies own their works as they would own a large department store, without regard to the public interest. And if the water works are taken away from them, they look upon it as the taking away of a business which belonged to them just as strictly as if it had been what we consider a private business in which public interests had no place.

As I look at the matter, I certainly agree with Mr. Eaton in his suggestion that there is a franchise value, or whatever you please to call it; there is a certain value in a water-works system for which the company is entitled to receive compensation. On the other hand, when a company is given the right by the legislature to take a water supply — and they always try to take the best to be obtained, and the one that can be the most economically developed — certainly they are given something that is on broad principles the property of the public, they are given something in which the public has rights. When a company is given the right to supply the public with water, it is, I believe, upon the theory that it is first for the convenience and benefit of the public, and, secondly, to enable it to make a reasonable profit for itself. It certainly should have a reasonable profit. I have no sympathy whatever with the idea that a municipality may take a water-works system because it has become a paying investment after years of work in building it up, and pay for it the bare cost of the physical plant. Surely there is something of value besides that. However, I do not believe that a company should have compensation given to it on the basis of a very large bonus over and above the value of that plant; that is to say, I do not believe that it is fair to pay for it on the basis of the capitalized revenue, in which the rates are more than reasonable; that is, the company should be paid for all of its work and expense, and a fair and reasonable profit, but it should not be paid for rights that have been intrusted to it by the legislature with which to serve the public, nor should it be given any monopoly value.

Now, of course, there is a question as to what are reasonable rates. I think you will all agree with me that it cannot be said that the rates in one town are reasonable or unreasonable because in another town, or in several other towns, the rates are higher

or lower. I do not believe that has very much to do with it. Each town has its own conditions of cost, and the rates to be reasonable should be based on those conditions. I should suppose that the reasonableness of rates rests mainly on the return which the company receives for its money.

The opinion of the court on these Maine cases, as I read it and understand it, was that the question of reasonable rates should have its influence on the award for compensation. Now, if rates are reasonable, or such as will give a company a reasonable rate of return upon its investment if they are to be made reasonable, then, if the award is made upon the capitalization of net revenue, it isn't going to give a tremendous bonus. As I said before, I think it is perfectly right for a company to make a good, reasonable profit, and it is entirely out of the question to expect to get water works, or the water, on the basis of the value of the physical plant only, without taking into consideration the value of the franchise or the value of the property as a going concern.

I have always been, in these cases, on the side of the municipality, not from any special choice of my own. I have the pleasure of doing other kinds of engineering work for a great many companies, but I have not been employed by companies on these valuation cases, and I suppose I am known in this connection as a municipal man. I try, however, to look at the question upon both sides and I know that there is a chance for an honest difference of opinion.

It seems to me that when works of this kind are being valued, unless it is otherwise provided for by charter or agreement, it should be on a capitalization basis, and I should like to say just a word here upon that point. There is a great deal of opposition to valuing these plants on a capitalized basis, but I cannot see, from either side of the question, why that should be opposed if it is done fairly. We will all of us agree that the cost of a thing is not always its value; there are some other considerations that come in to make up the value. For instance, if a water works was not bringing in a revenue sufficient to meet expenses, and pay interest upon the cost, no one would want to pay for those works the full cost of their construction. Now, on the other hand, why should not there be a certain increase over the cost of the con-

struction if they are paying a profit, to compensate a company for its risk in the original undertaking and its enterprise in establishing and building up the works by capitalization?

I was going to say that on that basis of valuation — and I believe that most of the works have really been valued on that basis, with a great deal of regard, at least, to that basis — everything in the way of operating expenses should be considered in ascertaining the net revenue. The true net revenue is not the gross revenue less the operating expenses, if you do not consider the depreciation of the plant. Any business man, carrying on a business in a proper way, makes provision for the depreciation of his plant. So, in a water-works system, a certain amount should be provided each year for depreciation of the plant, as municipalities do by their sinking fund, and that amount should be deducted, in addition to the operating expenses, from the gross revenue. To deduct simply the operating expenses from the gross revenue is a false way of getting at the net revenue and gives an improperly high value.

When you take all those things into consideration, and when you take into consideration, to a certain extent, the reasonableness of the rates, capitalizing the net revenue will not provide an excessive bonus over the value of the plant itself.

Prof. E. G. Smith. Regarding the valuation of the franchise, I have never been able to satisfy myself as to the difference between valuing the franchise — which, after all, is merely a contract — and the waterworks as "a going concern." Out West we do not believe in selling a franchise, but the works are looked at as a going concern, for the franchise can have no value if it does not give some value to those who own it.

Respecting this matter of public and private ownership, there is another interesting question brought up besides that of the valuation of water works. In the West, where change from private to public ownership is going on, it is not accomplished by the establishment of a new district, as has been here brought out, but it is done under laws which allow a city to enter into contract with a private company.

The city of Kenosha, Wis., could not raise the money to establish a water system since it was bonded to the full extent, as is

unfortunately, the case with so many of our western cities, but it was possible to raise money for operation by direct taxation, by increasing the rate. Therefore it entered into a contract with a private company to build the plant, the sums which were paid in annually establishing a sinking fund which, after a certain period, would allow the return of the plant to the city. This plan has been passed upon by the Supreme Court of Wisconsin, and several cities in our state have had their works put in under this method. Of course the works ultimately revert to the city and become its property.

I hope that this extremely important paper by Mr. Eaton will be printed, and along with it the decisions of the court which he refers to. It is really an epoch-making work which has been done here, and this paper itself, and the decisions which Mr. Eaton has mentioned, the rulings of the lower and the upper courts, should have a wide circulation.

Regarding this matter of public and private water works I want to say that the Mississippi River drains a territory having a population of upwards of six millions of people from its upper to its lower extent, a population which is bound to increase. And this river, receiving as it does the drainage from this immense population, is yet the water supply of a good portion of that population.

Between Brainerd, Minn., on the north, and New Orleans on the south, not including the influent streams, there are, as has been said, twenty-six cities taking their water supply directly from the river, and of this number eighteen of the works are owned by cities or towns upon the banks, and eight of them are operated under private franchises by private corporations. Of these eight private works there is but the one, Brainerd, Minn., which has not a filtering plant, and it supplies a population of only seven thousand at the upper reaches of the river where the water is relatively pure.

The population supplied by water from the Mississippi River is almost one and a half millions; 275 000 people out of this one and a half million are supplied by private corporations, and only about seven thousand of this number are left unprotected by filtration of the water. On the other hand, of the eighteen cities and

towns supplied under public ownership, but three of them — those at Dubuque, Iowa, and at Moline and Rock Island, Ill.— filter their water or attempt to filter it in any way. And of the three cities mentioned, Dubuque takes but very little water from the river, the supply being largely from artesian wells, and at Rock Island the filter plant is unsatisfactory, leaving Moline the only city which filters the supply of water, and there the plant has been installed only since last spring. So that of this million and a half population, about a million and a quarter are supplied with water under municipal ownership, and of that number not to exceed seventy-five thousand people have a nominal protection of filtration. The other fifteen cities and towns, representing a population of about twelve hundred thousand people supplied under municipal ownership, have little protection as to the purity of their water.

This is an astonishing showing, but it brings out the other side of this question. Everybody's business, I suppose, is nobody's business. I do not say that the water companies are great charitable institutions established for the health of the people and the benefit of the nation at large. But they are alive to the public demands for waters of good quality, and suitable for all purposes, and the attempt is made to establish and operate purification plants of as high efficiency as the present condition of the science of filtration and purification can offer. Undoubtedly pressure is brought to bear upon them in order to produce results, but the facts along the Mississippi River are as I have stated.

I have been extremely interested in this question, and I think that the discussion you have here is very far-reaching. I, for one, feel very much indebted to Mr. Eaton for the splendid way in which he has brought out to us, so clearly and so fully, the work which has been done in Maine, and for the struggle which he has officered through in such a splendid manner.

THE KENNEBEC VALLEY TYPHOID FEVER EPIDEMIC OF 1902–1903.

BY GEORGE C. WHIPPLE * AND DR. E. C. LEVY.†

[*Read February 8, 1905.*]

The recent appraisals of the water works of Waterville and Augusta, Me., necessitated a careful study of the typhoid fever epidemic which swept through the Kennebec Valley during the winter and spring of 1902–3. At the time when this epidemic occurred the plan of municipal ownership through the agency of "water districts" had been suggested and the law had been pronounced constitutional by the courts. The bad quality of the water supplied to these communities had much to do with this demand for public ownership, and the outbreaks of typhoid fever naturally hastened the actions which had been contemplated. The epidemic itself presented no novel features and its history is much the same as that of many other epidemics of typhoid fever due to public water supplies. Its magnitude, however, makes it deserve a place among the important epidemics of the country.

The detailed study made necessary by the fact that testimony regarding the sanitary quality of the water supply was to be presented at the hearings and considered by the court in appraising the value of the water works is perhaps worthy of record. It is quite possible that the time may come when water companies and cities will be held legally responsible for the loss of life occasioned by such epidemics, and should this occur it might be necessary to prove in court the cause of the epidemic and the agency of the water as a distributor of infection. Those who are familiar with legal proceedings will recognize that to do this is not as easy as to study an epidemic from a purely scientific standpoint. The subject viewed in this aspect is therefore worthy of careful consideration by the members of this Association.

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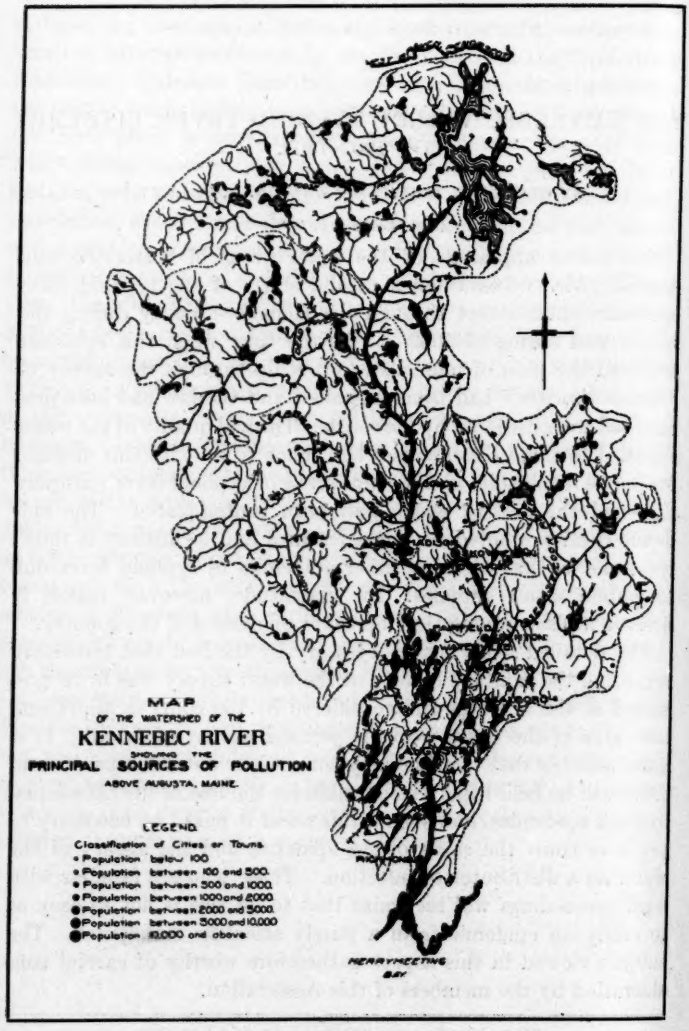
MAP
OF THE WATERSHED OF THE
KENNEBEC RIVER
SHOWING THE
PRINCIPAL SOURCES OF POLLUTION
ABOVE AUGUSTA, MAINE.
LEGEND.
Classification of Cities or Towns.
Population below 100
Population between 100 and 500.
Population between 500 and 1000.
Population between 1000 and 2000.
Population between 2000 and 5000.
Population between 5000 and 10,000
Population 10,000 and above.
MERRYMEETING BAY

FIG. 1.

In order to understand the course of the epidemic it will be necessary to sketch briefly the geography of the region so far as it relates to the water supplies of the cities involved.

GEOGRAPHICAL.

The Kennebec River drains a region, shown in Fig. 1, situated in the central part of Maine. It rises north of Moosehead Lake and flows in a southerly direction into Merrymeeting Bay, where it unites with the waters of the Androscoggin River and discharges ultimately into the Atlantic Ocean. It has a total watershed of about 6 359 square miles. The flow of the stream varies considerably at different seasons, although the storage at Moosehead Lake tends to keep it more uniform than many of the rivers of the state. There are several excellent water-powers along the stream and on its tributaries, and these water-powers have formed the nuclei of most of the cities and towns in the valley. The most important tributaries of the Kennebec River below Moosehead Lake are the Dead River, the Carrebasset River, Sandy River, the Messalonskee River, the Sebasticook River, and the Cobbosseecontee River. The most important cities and towns along the river are Solon, Anson, Madison, Norridgewock, Skowhegan, Fairfield, Waterville, Winslow, Augusta, Gardiner, Hallowell, and Richmond. It is with Waterville, Fairfield, Winslow, Benton, Augusta, and Richmond that this paper has to do. The location of these cities and towns is shown in Fig. 1.

All the cities and towns along the river naturally drain into the stream, so that in the lower courses of the river the water is considerably polluted. This is shown by Tables No. 1 and No. 2, which give the population per square mile and the amount of sewage and manufacturing wastes entering the stream at various places above Augusta, and also in Fig. 2, which shows the drainage areas and populations above various points.

The city of Waterville and the neighboring towns of Fairfield, Winslow, and Benton, were, at the beginning of this investigation, supplied by the Maine Water Company with water from the Messalonskee stream. This stream has a watershed of 205 square miles above the pumping station and drains a chain of seven large

lakes which have a combined water surface of 27.5 square miles. Upon this watershed there dwells a population of something over five thousand persons, or about twenty-seven per square mile. The upper portions of the watershed are comparatively unpolluted, but at the outlet of Messalonskee Lake is the town of Oak-

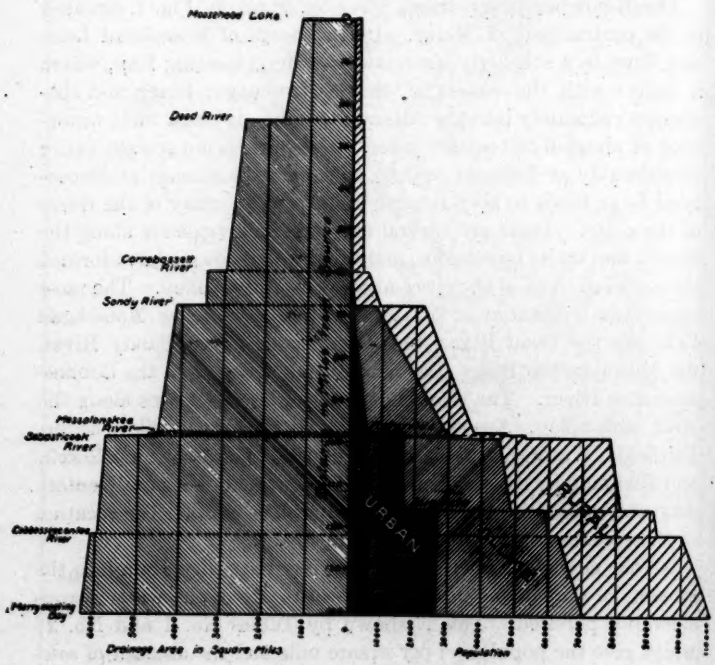

FIG. 2. — DIAGRAM SHOWING THE DRAINAGE AREA AND POPULATION ABOVE VARIOUS POINTS ON THE KENNEBEC RIVER.

land which has a population of approximately two thousand. At this place, which is only seven miles above the pumping station of the Maine Water Company at Waterville, sewage is discharged from several private sewers. Along the stream are a number of mills, the most important of which are the Oakland and Cascade

Woolen Mills, the mills of the Dunn Edge Tool Company and the Emerson and Stevens Company. They contribute not only a considerable amount of fecal matter, but wool washings, dye stuffs, and other kinds of manufacturing wastes. The Messalonskee River between Oakland and Waterville flows rapidly during the first half of its course and then somewhat more slowly as it feels the effect of the backwater of the water-works dam. The time required for the water to flow from Oakland to Waterville is often only a few hours. The Maine Water Company had also the right to use the water of the Kennebec River. This water has been seldom used, although just prior to the epidemic it was pumped into the city for a short time because of a fire which occurred at Colby University. During the dry spell of last autumn (1904) it was again used, as the flow of the Messalonskee became insufficient to operate the pumps.

As might be naturally expected from the surroundings, the water at the pumping station of the Maine Water Company showed decided indications of pollution. Under ordinary conditions the water was light colored and fairly clear, but after rains it became turbid and heavily laden with bacteria. At all times the intestinal germ, *B. coli*, was present in large numbers.

Prior to 1901 the typhoid fever death rate in Waterville had not been especially high. During 1901 and 1902, however, the rate increased to more than 80 per 100 000, but it was not until the autumn of 1902 that the typhoid situation became serious.

The city of Waterville is fairly well provided with sewers, and at Waterville, Winslow, and Fairfield there are a number of mills which have privies directly over the stream.

About eighteen miles below Waterville is the city of Augusta, the capital of the state. Augusta takes its water supply directly from the Kennebec River at a point just above the city near the Kennebec Dam. Until recently the works were owned by the Augusta Water Company. The river water was pumped to a reservoir, but was first passed through an old Warren filter, one of the first of its kind in America. This was a filter only in name, and should have been more properly called a strainer. Analyses indicated that its bacterial efficiency was practically *nil*. As would be naturally expected, the river water at Augusta was

found to be polluted. This was shown by the analyses which were made daily for several months, but it was even more strongly demonstrated by the typhoid fever statistics of the city.

The water of the Kennebec River just below Waterville showed at all times evidences of gross pollution. During its flow of seventeen miles to Augusta its bacterial quality appeared to improve somewhat. In the summer this improvement was much more noticeable than during the winter, when the river was covered with ice. Float experiments which were made indicated that the time required for water to flow from one place to the other was about three days at times when the discharge of the stream was small. At times of flood this period is probably not much, if any, more than twenty-four hours.

The Augusta Water Company also controlled and used a spring water supply known as the Devine water. In some houses this was used exclusively, in others both this and the river water was used. The quality of this water was poor, but better than that of the river.

The sewers of Augusta discharge into the river and there are several mills along the shore which pollute the water.

The town of Richmond, fifteen miles below Augusta, also takes its water supply from the Kennebec River. The conditions there are such that the main current of the stream flows to the east of Swan Island, while the intake of the water works is located in the west channel. The river at Richmond is considerably affected by the tides; in fact, the town water is at times brackish. Thus, while the town uses the water which receives the sewage of Augusta, Waterville, and other cities, the tidal conditions tend somewhat to lessen the effect of this up-stream pollution, although they increase the danger from local sources.

GENERAL ACCOUNT OF THE TYPHOID FEVER EPIDEMIC.

The typhoid fever epidemic of 1902–3 began about the middle of November, 1902. It was first noticed at Waterville, where for about a month new cases were reported at the rate of one a day. On Christmas day there were five new cases and during the next week the daily number of cases was the same. Thirteen were reported on New Year's day. After the middle of January

the number of new cases fell off, but they continued to be reported at intervals until March. In Fairfield, Winslow, and Benton, typhoid fever occurred at the same time. The largest number of cases was reported during the first two weeks of January. These four communities had the same water supply, namely, that of the Messalonskee River, and from the first it was evident that this was the cause of the epidemic.

As the sewage of these typhoid fever stricken communities emptied into the Kennebec River and as the water of this river furnished the supply of Augusta, it was almost inevitable that the epidemic should extend to that city also, and this is what actually occurred. During the latter part of November and the whole of December new cases of typhoid fever occurred daily in Augusta. It seems probable that these earlier cases were due to the same source of infection that caused the epidemic at Waterville, inasmuch as the Messalonskee River which supplied that city discharges into the Kennebec above Augusta. It was not until about two weeks after the climax of the Waterville epidemic that the serious period of the Augusta epidemic began. During the latter part of December and throughout the months of January and February the sewage at Waterville must have been infected with typhoid fever bacilli; and, making due allowances for the periods of sickness, transmission, and incubation, this time corresponded with the duration of the epidemic at Augusta. After the Waterville epidemic had ceased and sufficient time had elapsed for the patients to recover, the epidemic at Augusta came to an end.

At Richmond, which is only a small village, typhoid fever did not occur until the middle of January, but occasional cases appeared during the next two or three months and were plainly connected with the epidemic of the cities above.

The city of Gardiner is situated between Augusta and Richmond. It does not take its water supply from the Kennebec River, but from the Cobbosseecontee River. This city had no epidemic, although a number of cases of typhoid fever occurred there. Most of these were contracted at Augusta. The same was true also of the town of Hallowell.

Fig. 3 shows chronologically the progress of this epidemic, together with certain factors which affected it. It indicates

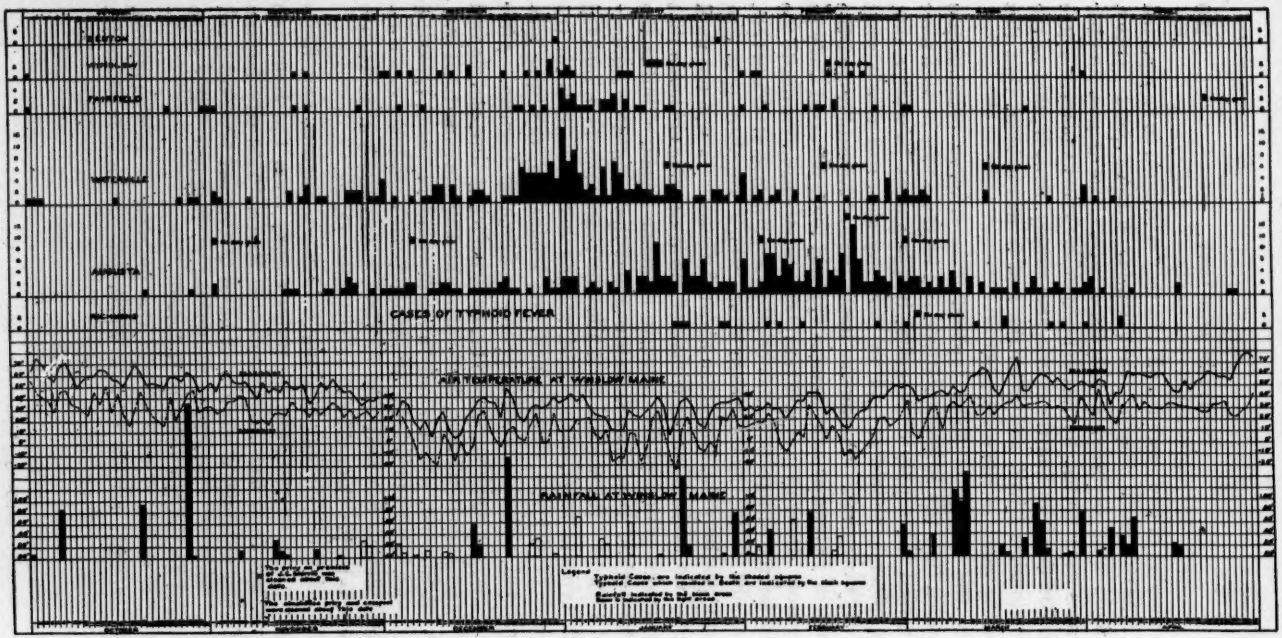

FIG. 3. — DIAGRAM SHOWING THE CHRONOLOGICAL DISTRIBUTION OF TYPHOID FEVER CASES IN WATERVILLE, FAIRFIELD, WINSLOW, BENTON, AUGUSTA, AND RICHMOND, MAINE, FROM OCTOBER, 1902, TO APRIL, 1903.

that the epidemics in the different communities formed a connecting series and may be really considered as one epidemic, inasmuch as they started from a common cause. In all there were about 612 cases and 53 deaths.

INVESTIGATION OF THE EPIDEMIC.

The investigation of the Kennebec Valley typhoid fever epidemic was made with unusual completeness. It was not only desirable to ascertain the cause of the infection and the agency of transmission in order to protect the health of the citizens, but it was necessary to prove beyond a doubt whether or not the water supply was a potent factor in spreading the disease, as the quality of the water was intimately involved in the valuation of the water works, both at Waterville and Augusta. In January, 1903, one of the writers* was retained by the Kennebec Water District to investigate the quality of the water supply and to study in detail the relation between it and the typhoid fever epidemic above described. In August he was also retained to make a similar investigation for the Augusta Water District. The whole investigation included a thorough sanitary survey of the watersheds of the Kennebec and Messalonskee rivers, a long series of analyses of the water supplies and a study of the epidemics above mentioned, besides many local studies of a subsidiary character. Incidentally, investigations were made looking towards the future supplies of both cities. It was necessary not only to study all of these subjects from a scientific standpoint, but to prepare the data in the form of legal evidence to be presented in court. This paper relates only to those portions of the work which had to do with the typhoid fever epidemic.

TYPHOID FEVER IN WATERVILLE.

In studying the Waterville epidemic the first step taken was to secure with as much accuracy as possible certain information in regard to each case of typhoid fever. Printed forms, a sample

* This work was in charge of Mr. Whipple. At Waterville he was assisted by Dr. E. C. Levy; at Augusta, by Mr. Langdon Pearse, Sanitary Engineer, and by Dr. H. L. Russell, bacteriologist of the State Laboratory of Hygiene. Similar investigations on the part of the private water companies were made by Mr. James M. Caird, assisted by Mr. Percy N. Coupland, bacteriologist.

WINSLOW, BENTON, AUGUSTA, AND RICHMOND, MAINE, FROM OCTOBER, 1902, TO APRIL, 1903.

of which is given below, were first distributed among the physicians, who were requested to fill them out and furnish any other important facts known to them in regard to each case of typhoid fever which they had attended.

Typhoid Fever Record.

Case No. .....
Name .....Residence .....
Sex .....Age .....years ..... months .....
Nationality .....Occupation .....
Attended by Dr. .....of .....
Date of first symptoms.....First saw physician .....
Where living for month preceding illness, including absences from home....
.....
Source of water used regularly for drinking:
1. At home .....
2. At place of business .....
Other water occasionally drunk .....
Milk supplied by .....Address .....
Ice .....
Other cases in house .....
Other cases among business associates .....
Other cases where visiting .....
Were stools disinfected during illness?.....
Termination of illness { Recovery, date of leaving bed .....
Death, date .....
Number of people in house .....
Remarks: .....
.....
.....
Date of above report .....Information given by .....

While waiting for the return of these blanks from the physicians, the records of the local Board of Health were consulted. As fast as the returns were received from the physicians, each house where a case of typhoid fever had occurred was visited by an inspector, who examined the surroundings, checked up the data recorded upon the blanks, and obtained as many additional data as possible. He also secured the name of the person furnishing the information, in case it became necessary to call witnesses in court, and finally signed the completed record. Duplicate copies of the blanks were made with carbon paper and one of each placed in a

safe to guard against possible loss. The results were then tabulated for study and in some instances expressed graphically.

Data were also collected regarding the previous history of typhoid fever in the city. Similar data were obtained from Fairfield, Winslow, and Benton. These tables, No. 3 to No. 9, were used in the Waterville hearing before the Board of Appraisers.

The first typhoid canvass was followed by a complete house-to-house canvass throughout the four places above mentioned, primarily in order to secure data in regard to the water used, but also to obtain information as to the distribution of typhoid fever among users of different classes of waters. This not only accomplished its immediate object, but brought to light a number of additional cases of typhoid fever which the physicians had failed to report, some of which might be classed as "walking cases." No case however, was included in the final compilation until it had the indorsement of the attending physician.

It is not necessary to relate in detail all the steps that were taken. Studying the etiology of the epidemic by the method of elimination, all possible causes other than the public water supply were readily excluded. It could not have been caused by flies, because at the season of the year when the epidemic started, there were no flies. Ice was excluded, because during the winter practically no ice was being used. Oysters were eliminated, because very few of them were consumed in the city, and because a very large part of the epidemic occurred among the French-Canadian laboring people who seldom purchased them. Furthermore, the extended territory covered by the epidemic was in itself sufficient to exclude the above agencies. Milk was excluded as a general cause, because the data collected indicated, as shown in Fig. 4, that the cases of typhoid fever were not concentrated among the customers of one or a few milkmen, but were well distributed among the different dealers. The distribution was found to be roughly proportional to the size of the business and the number of cows kept. It was a singular fact that there was no case of typhoid fever among the customers of J. W. Morrill, in whose family one of the initial cases of the epidemic occurred.

Vended spring waters were excluded, because the users of this class of water suffered far less than others, because the spring

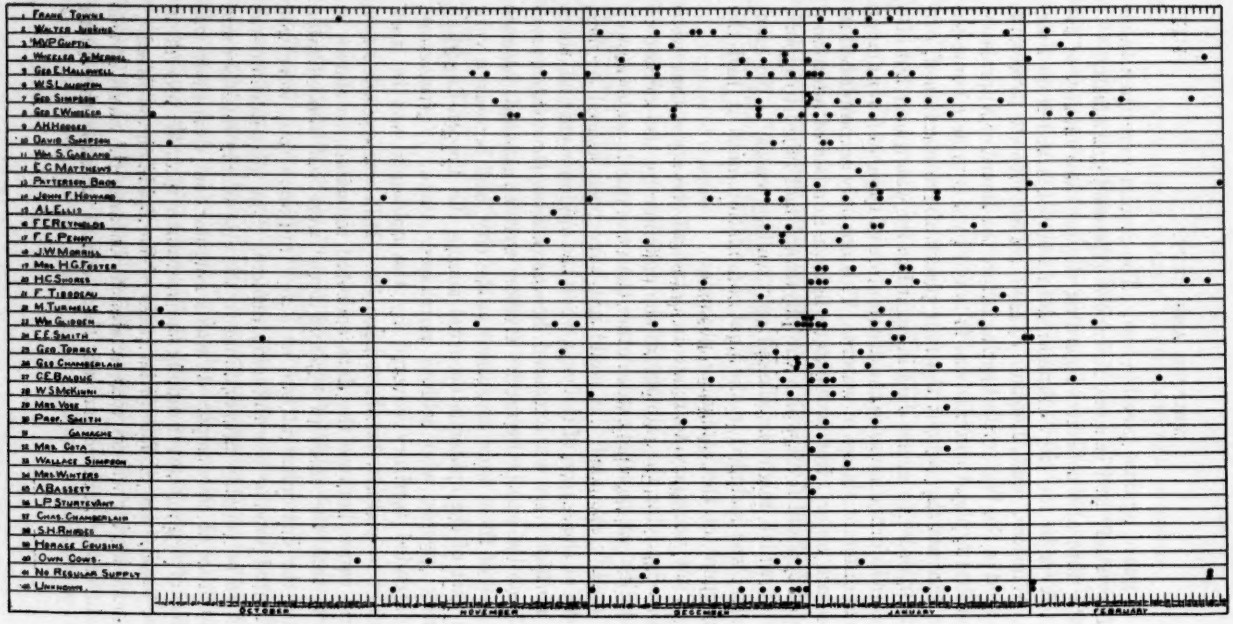

FIG. 4. — DIAGRAM SHOWING THE DISTRIBUTION OF TYPHOID FEVER CASES AMONG CUSTOMERS OF THE MILK DEALERS IN WATERVILLE, MAINE, BETWEEN OCTOBER 1, 1902, AND MARCH 1, 1903.

waters gave excellent analyses and because the water from no single spring, or group of springs, was used over the entire territory affected. The local wells were studied by us to some extent and quite extensively by Mr. Caird. Many were found to be polluted, as would be naturally expected from the local conditions, but there was no evidence by which infection could be traced to any one of them.

Practically the only cause left for serious consideration was the public water supply of the city, the cause to which everything had directly pointed from the start. The general distribution of the cases over an extensive territory (the various parts of which had in common no possible causative factor other than the water supply), as shown in Fig. 5, the chronological sequence of the cases, the fact that in practically every instance the patients gave a history of having regularly or occasionally drunk the water in question, the data obtained as to the relative prevalence of typhoid fever among users and non-users of this water throughout the district, and, lastly, the discovery of the actual means by which the water had in all likelihood become infected, — all these things indicated with as much positiveness as is possible with circumstantial evidence that it was the public water supply which was the general distributing agent of the infection.

For some time prior to the epidemic, the character of the water supply of the city had been such as to lead to a quite general use of spring water, which was peddled by several dealers and purchased by most of those who could afford it. Well and cistern waters were used to a considerable extent. The water of the Kennebec River was used at a number of the mills and in some residences, especially in Winslow. The figures obtained in the general canvass and given in Tables No. 8 and No. 9 were of considerable interest in this connection. They showed that the morbidity rate for the epidemic period among those who used Messalonskee water exclusively was 42.00 per 1 000; while among these who used Messalonskee and some other water it was 14.55. If from the latter class there were excluded those who used water from the Kennebec River, which at Waterville is more or less polluted, the morbidity rate was found to be only 8.74. It is not to be expected that even in this group there would not be some who had

FIG. 4. — DIAGRAM SHOWING THE DISTRIBUTION OF TYPHOID FEVER CASES AMONG CUSTOMERS OF THE MILK DEALERS IN WATERVILLE, MAINE, BETWEEN OCTOBER 1, 1902, AND MARCH 1, 1903.

occasionally used water from the Messalonskee supply, for, as a matter of fact, there were only five of the Waterville typhoid patients who did not remember to have used this water at any time before being taken ill.

The figures given show emphatically that the morbidity rate was highest among those who used the Messalonskee water exclusively and lowest among those who did not use it. It must be remembered, of course, that in any epidemic there are always some cases contracted by direct infection from other cases.

In Fairfield, many of the houses were supplied by water piped from a spring by a private company. Not a single case developed among the takers of this water.

ORIGIN OF THE EPIDEMIC.

As soon as it had become evident, not only from the exclusion of other possible causes but from certain well-marked positive features of the situation, that the epidemic was due to drinking water, a search for the actual origin of the infection of the public water supply was begun. Our attention naturally was first directed to Oakland, as this was the only settlement of considerable size on the Messalonskee River above Waterville. Inquiry among the Oakland physicians elicited the information that there had been but one case of typhoid fever there during the preceding summer and fall, up to the beginning of the Waterville epidemic. This case had been imported from Winslow. An inspection of the premises where the patient resided convinced us that this could not possibly have been the starting point of the Waterville epidemic.

Very soon after the returns from the typhoid canvass began to come in, two possible sources of infection of the city water supply suggested themselves, and further investigation of these rendered it reasonably certain that each of them had offered abundant opportunity for the infection of the Messalonskee River.

The first of these foci was at the city almshouse, located in the suburbs of Waterville near the Messalonskee stream, as shown in Fig. 5. A typhoid fever patient, Joe King, was admitted there on September 22, 1902. His attack was a mild one and confined him to bed for only a week. After leaving his bed, however, he remained five days longer at the almshouse, and dur-

ing this latter period no attempt was made to disinfect either excreta or urine, which were deposited sometimes in a privy in the yard and sometimes in a watercloset which drained into a cesspool on the premises. On November 6, 1902, the privy and cesspool were cleaned and their contents spread upon the almshouse garden, the ground being frozen at the time. This was only a few hundred feet from the Messalonskee River, into which it drained. The slope of the intervening land was quite steep and there was also a distinct gully which showed every sign of carrying a considerable and rapid flow of water across the garden and into the river after heavy rainfalls.

The second focus of infection was found about a mile outside of Waterville, on the other side of the stream. During 1902, there had been five cases of typhoid fever in the families of J. W. Morrill and J. C. Morrill, who lived in farmhouses situated just across the road from each other. In all of these cases except one, a prompt diagnosis had been made and the fecal dejecta of the patients had been disinfected and buried daily. In the second case of the series, however, the patient, Mrs. Studley, had been ill several weeks before the diagnosis of typhoid fever was made. During this time, *i. e.*, from September 1 to September 25, no sufficient disinfection of stools was practiced, but they were emptied directly into a privy vault. Later on, at some time early in November, the contents of the privy were deposited in a field at a point where the land sloped abruptly towards a rivulet, about 200 feet away. After flowing about three quarters of a mile, over a very rapid course, this brook emptied into the Messalonskee River almost directly opposite the almshouse above mentioned, about one mile up-stream from the intake of the water works. (See map, Fig. 5.)

Thus, early in November, 1902, there were typhoid dejecta deposited upon the surface of the frozen ground at two points above and relatively near the pumping station of the Maine Water Company. In each case there was a sharp slope from the point where the dejecta were deposited, — to the Messalonskee River in the one case, and in the other to a small rill which emptied into the river. If these were the sources of infection, one would expect that, from this time on, the occurrence of typhoid fever among

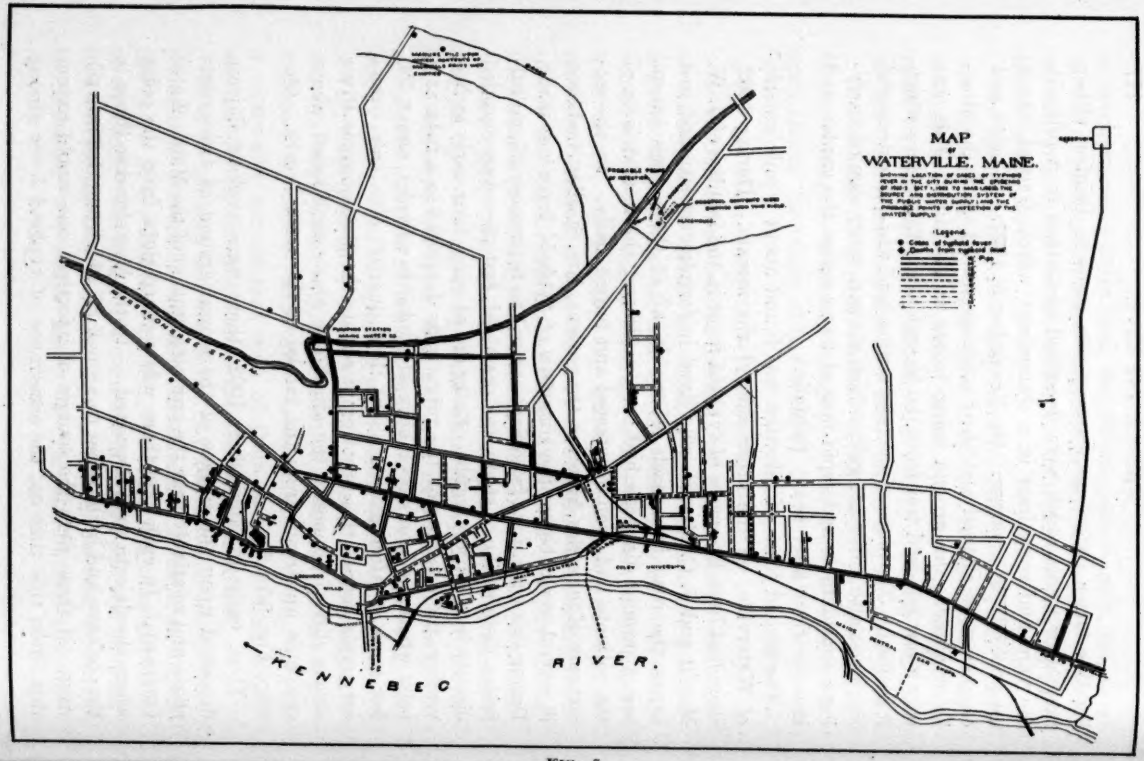

FIG. 5.

users of the Messalonskee water would bear an intimate relation to the rainfall. This relation was found to exist.

Fig. 3 shows the date of occurrence of the typhoid fever cases, as determined by the date of physician's first visit, — which was found to be in most cases the day when the patient took to bed, — in Waterville, Fairfield, Winslow, and Benton, during the months of November, 1902, to February, 1903. The daily rainfall as recorded at Winslow is also shown. From this table it seems that during the early part of November there was only what may be considered a normal number of typhoid cases for this season. The first rainfall of considerable extent after infectious material was deposited in the fields was on November 12, when there was .30 inch. This was followed by a small group of cases towards the end of the month. The precipitation between November 23 and December 16 was snow, and this, gradually melting, probably washed small amounts of infectious matter into the river, which gave rise to the cases which developed up to about December 24. On the 16th day of December, there was a precipitation of .56 inch, rain and snow, and nine days later, December 25, the real epidemic may be said to have begun, with the development of six cases of typhoid in Waterville and one in Fairfield. From December 25 to the end of the month there were 37 cases in Waterville, 5 in Winslow, 3 in Fairfield, and 1 in Benton, a total of 46 cases in one week.

The heaviest rainfall after the infectious material was deposited on the fields at Morrill's and the almshouse occurred on December 22, 1902, when there was a precipitation of 1.73 inches. Ten days after this, or almost exactly the same interval as after the rainfall of December 16, there developed the greatest number of cases of any day during the epidemic, namely, 13 cases in Waterville, 4 in Fairfield, and 1 in Winslow, a total of 18 cases.

Throughout the two months from the last third of November until the corresponding time in January, the relation between the rainfall and the typhoid cases was manifest as shown in Fig. 3. By the middle of January the typhoid bacilli in the two mentioned fields had either lost their vitality, or, what is more likely, had been pretty thoroughly washed away; for a rainfall of 1.40 inches on January 21 was not followed by any serious consequences.

The constant relation between rainfall and the development of typhoid fever cases was in itself a strong argument in favor of the agency of the public water supply in causing the epidemic.

In attempting to prove the case in court there were produced as witnesses the physician who attended the initial cases, the persons who spread the cesspool and privy contents on the fields, the inspector who had charge of the typhoid canvass, and the writers who collected the data and made the various investigations here referred to.

Although it is impossible in a paper of this length to give details of every piece of evidence presented, it may be well to take notice of a plausible objection to the above theory which might have been brought forward. During the early part of the epidemic Fairfield did not have as many cases in proportion to its population as did Waterville and Winslow, although supplied to a great extent by the same water. This was readily explained by a consideration of certain features of the distributing system. The reservoir of the system is located between Waterville and Fairfield and is supplied by a single pipe line, which branches off from the main connecting the two cities. From this arrangement it follows that when the consumption in Waterville and Winslow is less than is being pumped, both places receive water directly from the pumps, the excess going to the reservoir. When, on the other hand, the consumption is greater than the amount pumped, Fairfield and Benton receive water which has been stored in the reservoir. This fact was proved experimentally during our investigations by making several series of analyses at various points in the system. The older water in the reservoir, which had received some sedimentation, would be theoretically less infected with typhoid bacilli than the water pumped directly from the river; and theory, in these cases, certainly agreed with the facts. The facts also indicated that the use of the Kennebec River water at the time of the Colby University fire could not have been the cause of the epidemic or have materially contributed to it.

From the standpoint of the appraisal, the point to be established was not that the two cases mentioned were or were not the cause of the epidemic, but that *the public water supply* was or was not

responsible for it. All the studies were incident to this main proposition.

TYPHOID FEVER IN AUGUSTA.

The methods used in studying the epidemic in Augusta were similar to those employed at Waterville. The house-to-house canvass was perhaps more thorough, but on the other hand it was made several months after the epidemic was over, when the facts were not so fresh in the minds of the people. The studies of the previous history of typhoid fever in Augusta were much more important than in the Waterville case, and the problem was much more complicated because the city had two sources of public water supply and the number of spring waters sold was greater.

PREVIOUS HISTORY OF TYPHOID FEVER IN AUGUSTA.

The Kennebec River water was introduced as a source of public water supply in the year 1887. For sixteen years before that time the average typhoid fever death rate in August had been 36.5 per 100 000; for sixteen years from 1888 to 1903 the average rate was 85.4. In 1898 there were a number of imported cases due to the Spanish War, and in 1903 occurred the great epidemic, which raised the death rate to 259 per 100 000. Excluding these two years, the average death rate during the period covering the use of the Kennebec River water was 66.5, or nearly double what it formerly had been.

At various times prior to 1903, typhoid fever had been prevalent in the city. Thus the board of health records for 1890 show that seventy-five cases of typhoid fever, besides a large amount of winter cholera, occurred that year. During the first thirteen weeks of 1891 sixty-nine cases were reported. There were no typhoid fever records kept at Waterville at that time, so it cannot be told whether or not the disease was due to infected sewage from that city. Typhoid fever was also prevalent during the winter and spring of 1892 and 1893. A report made by Capt. M. W. Wood, assistant surgeon, U. S. A., on June 2, 1893, states that there were about one hundred cases during the early part of that year.

Prior to the introduction of the Kennebec River water, typhoid fever in Augusta had been most common in the autumn, this

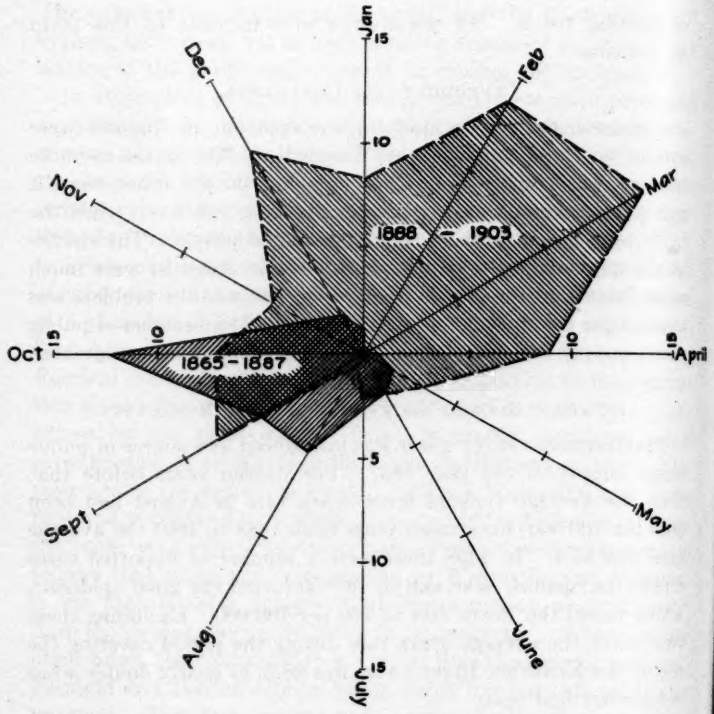

DIAGRAM SHOWING THE
SEASONAL DISTRIBUTION OF
TYPHOID FEVER
IN AUGUSTA MAINE
BEFORE AND AFTER THE INTRODUCTION
OF KENNEBEC RIVER WATER

The figures on the radial lines stand for monthly death rates.

FIG. 6.

being the normal season for the maximum of the disease, but after the installation of the supply from the Kennebec River the disease became most common during the winter months. This is an abnormal seasonal distribution, and is most easily explained by assuming the maximum of the disease at Augusta to follow and to be caused by the normal autumnal maximum of typhoid fever in Waterville and the other cities which discharge their sewage into the river above Augusta. This change in the seasonal distribution is shown in Fig. 6.

Both the abundance of typhoid fever and its seasonal distribution since 1888 pointed strongly to the pollution and infection of the river water and would have been sufficient to condemn it as a source of supply even if the epidemic of 1902–3 had not occurred.

The data compiled for the Augusta epidemic are given in Tables 10 to 17, and are shown graphically in Figs. 3 and 7. As in the case of Waterville, all possible agencies of infection other than water were one by one excluded from consideration. The canvass showed that the morbidity rate for those cases on premises supplied with river water only was 53.7 per 1 000; on those supplied only with Devine water, 12.3; and on those supplied by wells, springs, or cisterns, 23.6. On those premises supplied with river water with or without supplementary sources the morbidity rate was 29.2, while on those which had no river water the rate was 20.6.

Classifying the cases according to the statements of the patients as to their use of water it was found that of 336 cases 76 per cent. admitted that they had used the river water prior to being taken sick, while 24 per cent. of them did not remember to have used the water. Of the latter class, however, 65 per cent. lived on premises supplied with water from the river. Thus only about eight per cent. of the patients interviewed did not remember of having used the water and were not supplied with water from the river, at their homes. The conclusion that the river water caused the epidemic was inevitable.

Some of the data collected during the investigation are given in the tables referred to and need no special comment.

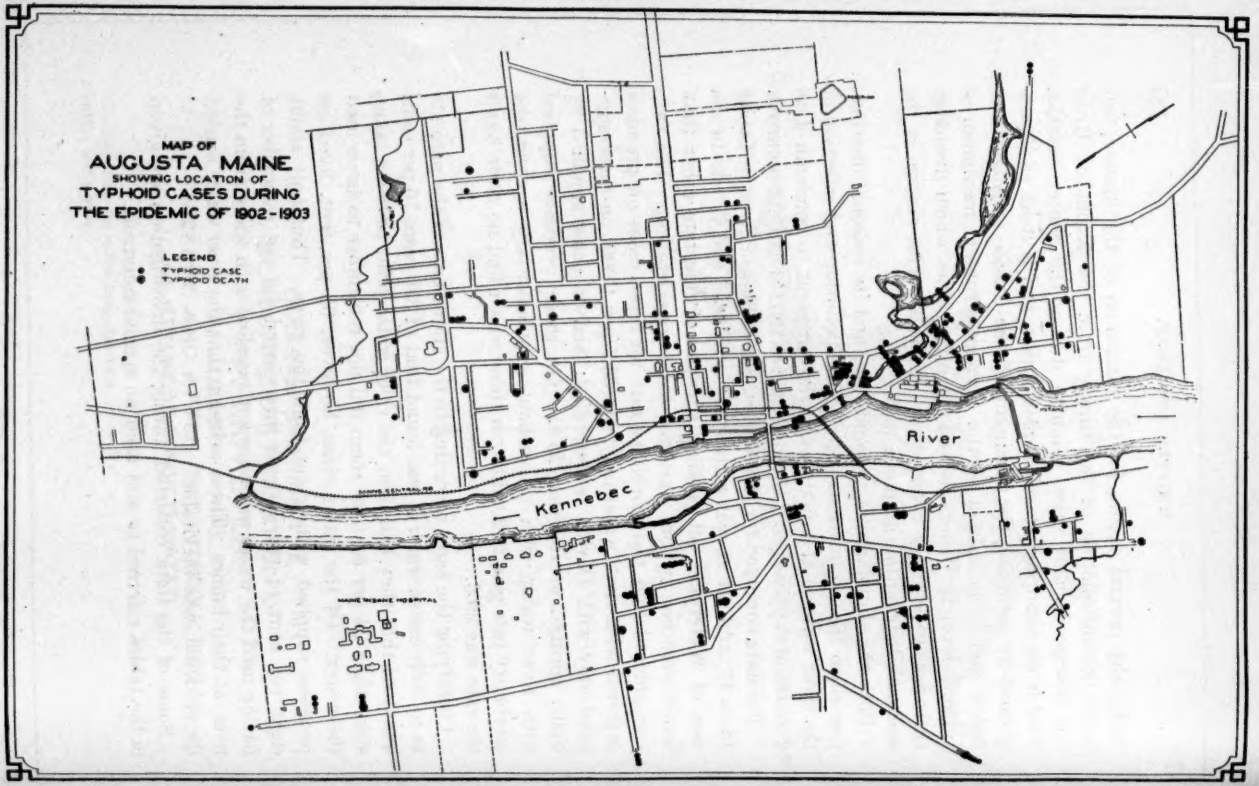
MAP OF
AUGUSTA MAINE
SHOWING LOCATION OF
TYPHOID CASES DURING
THE EPIDEMIC OF 1902-1903
LEGEND
TYPHOID CASE
TYPHOID DEATH
Kennebec
River
MAINE INSANE HOSPITAL

FIG. 7.

TYPHOID FEVER AT TOGUS.

The National Home for Disabled Volunteer Soldiers, Eastern District, is located at Togus, about six miles from Augusta. At the time of the investigation there were 2 260 members and 40 civilian employees. The Home was established in 1867 and its location was chosen because of the supposed medicinal virtues of a certain spring known as Togus Spring, which is still used by some of the members. Prior to 1887 the water supply of Togus was taken from Greely Pond, but as it was insufficient in quantity and not entirely satisfactory in its physical qualities, water from the Kennebec River was introduced in June, 1887. Between 1877 and 1887 not a case of typhoid fever occurred among the members, but during the fourteen years from July 1, 1887, to June 30, 1891, 25 cases occurred, which resulted in five deaths. When the old age of the members is taken into consideration this number appears large. The prevalence of typhoid fever at this time was attributed by Dr. Ellwell, surgeon, U. S. A., to the use of the Kennebec River water, and at his instigation a new supply was provided in 1892 from a spring known as the Hallowell spring. This is piped into most of the buildings and is almost exclusively used for domestic purposes. Its quality is good. Although the use of the Kennebec River water was forbidden, it was impossible to entirely prevent its use, and this probably accounts for the scattering cases of typhoid fever which have occurred there during the past twelve years. After the introduction of the Hallowell Spring water there was an almost immediate disappearance of the disease. No case of typhoid fever occurred at the Home during the epidemic of 1902–3.

TYPHOID FEVER AT THE MAINE INSANE HOSPITAL.

The state insane hospital is located in Augusta but has a separate water supply for drinking and domestic purposes. The Kennebec River water is more or less used. Between 1865 and 1887, with an average number of 404 patients, no deaths from typhoid fever occurred. This was before the introduction of the river water. Between 1887 and 1902 the average number of patients was 670 and the number of deaths from typhoid fever 6, which is equivalent to an annual death rate of 56 per 100 000.

TYPHOID FEVER AT RICHMOND.

The typhoid fever records of Richmond do not extend back of 1892. The city clerk's records for the years 1892 to 1903, however, indicate a death rate of 42 per 100 000 during these twelve years.

The typhoid fever canvass of Richmond was less complete than that of Augusta, but of the 19 cases which occurred between January and April, 1903, all were said to have used the river water, and there is little reason to believe that these cases were due to any other cause.

GENERAL TYPHOID FEVER SITUATION IN THE STATE OF MAINE.

For a number of years the death rate from typhoid fever in Maine has been greater than for most of the other New England states. Some of the cities have maintained death rates which reflect in the most uncomplimentary manner the quality of their public water supplies.

It is sad to have to recount that the epidemic of the Kennebec River was duplicated one year later on the Penobscot River. This epidemic has not been studied with as much care as the one described above, and all the circumstances are not fully known to the writers.* The general facts, however, were as follows:

The epidemic appears to have originated in Millinocket, a paper-mill town located about ninety miles north of Bangor. This village is said to be supplied with water from the river at two places, one above the town and one so near the town that it receives considerable pollution. Ordinarily the upper source is used, but early in the year 1904 a fire occurred which compelled them to use water from the lower intake. This was followed by an epidemic of dysentery, but no typhoid fever. A short time afterwards a second fire occurred, which again necessitated the use of the polluted water. This time an epidemic of typhoid fever resulted, which was so serious that it became necessary to call in physicians from outside the town in order to take care of the large number of cases which occurred. The infection passed

* Since the preparation of this paper the Penobscot River epidemic has been carefully investigated by Mr. Whipple in the interest of the Citizens' League of Bangor. The results only serve to emphasize the statements here made.

down the Penobscot River and affected Oldtown, Brewer, and Bangor, all of which places take their water from the river. At least seventy-five cases are known to have occurred in Oldtown, but complete data on this subject are not at hand. The epidemic at Bangor was studied with considerable care by a committee of citizens headed by Dr. Bertram L. Bryant. This committee published a series of interesting reports which appeared from time to time in the Bangor *Daily Commercial*, and which were afterwards published in pamphlet form by the Citizens' League. From this report it is learned that between March 1 and May 24, 1904, 540 cases of typhoid fever and thirty-three deaths occurred in Bangor. The committee estimated that one person in every forty of the people of Bangor had typhoid fever during these three months.

A sanitary inspection of the watershed was made by P. H. Coombs, civil engineer, who made a report which contained data as to the amount of sewage entering the river between Oldtown and Bangor. Analyses showing the quality of the river water were made by Prof. Franklin C. Robinson. The water supply of Bangor was filtered through a mechanical filter of an old type, but it was evidently entirely inadequate for the purpose of purifying the water. Strangely enough, almost no allusion is made in this report to the Millinocket epidemic as being the cause of the others, but this was undoubtedly the case.

The lesson of these two river valley epidemics ought to be taken seriously to heart by the sanitary authorities of the state of Maine. For a community to use as a public supply an unfiltered water taken from a river which receives the sewage of cities higher up is only to invite disaster. It is unfortunate that such conditions are not remedied before rather than after the occurrence of an epidemic. The cities of Waterville and Augusta and the cities of the Penobscot valley could have satisfactorily filtered their water supplies for a small part of what the epidemics cost them, and many lives might have been saved. The water companies in charge either did not appreciate the danger or they were not willing to incur the expense of rendering the water safe. One result of this situation is that the public water supplies are being taken away from the companies and purchased for the people by the so-called water districts.

Yielding to the popular prejudice against the use of the water which caused the epidemic, several cities have chosen to seek new supplies elsewhere. The new water supply for Waterville is to be taken from China Lake, and that for Augusta from Carleton Pond, both supplies being eminently satisfactory from a sanitary standpoint, and of such a character that they will not need filtration for many years to come. Brunswick is obtaining a new supply from driven wells. In many of the cities of the state, however, it would probably be cheaper to maintain their present sources of supply and protect the quality of the water by filtering it.

The state board of health of Maine now has a hygienic laboratory at Augusta, and in no way could this laboratory be made more serviceable than by establishing a systematic examination of the water supplies of the state in order to point out which of them are good, which are insecure in their sanitary quality, and which, if any, are dangerous. This should be supplemented by a sanitary inspection of the watersheds from which the various sources of supply are derived. To do this work would require a comparatively small increase in the appropriation, and its cost would be repaid a thousandfold, not only in dollars and cents, but in human lives.

TABLE No. 1.— Drainage Area and Population on the Watershed of the Kennebec River at Various Points.

Distance in Miles.	Drainage Area.	Drainage Area in Square Miles.		Population.								Population per Square Mile.							
				Rural.		Village.		Urban.		Total.		Rural.		Village.		Urban.		Total.	
0	Moosehead Lake, at outlet,	1 260		1 730		0		0		1 730		1.4		0		0		1.4	
	Between Moosehead Lake and Dead River,	378		210		0		0		210		0.5		0		0		0.5	
	Total above Dead River,		1 638		1 940		0		0		1 940		1.2		0		0		1.2
24	Dead River,	947		1 130		0		0		1 130		1.2		0		0		1.2	
	Between Dead River and Carrabasset River,	377		250		0		0		250		0.7		0		0		0.7	
	Total above Carrabasset River,		2 962		3 32		0		0		3 320		1.1		0		0		1.1
60	Carrabasset River,	439		3 370		0		0		3 370		8.0		0		0		8.0	
	Between Carrabasset River and Sandy River,	33		610		1 380		0		1 990		18.0		42.0		0		60.0	
	Total above Sandy River,		3 434		7 300		1 380		0		8 680		2.1		0.4		0		2.5
68	Sandy River,	732		6 820		6 330		0		13 150		9.0		9.0		0		18.0	
	Between Sandy River and Waterville,	400		3 520		6 760		5 180		15 460		9.0		17.0		13.0		39.0	
98	Total above Waterville,		4 566		17 640		14 470		5 180		37 290		3.9		3.2		1.1		8.2
99	Messalonskee Stream,	205		2 450		2 940		0		5 390		12.0		14.0		0		26.0	
	Sebasticook River,	1 041		11 580		13 760		0		25 340		11.0		12.0		0		23.0	
	Between Waterville and Augusta,*	115		950		2 060		10 480		13 490		8.0		18.0		91.0		117.0	
116	Total above Augusta,		5 927		32 620		33 230		15 660		81 510		5.5		5.6		2.7		13.8
122	Cobbosseecontee River,	230		5 470		3 070		0		8 540		24.0		13.0		0		37.0	
	Between Augusta and Merrymeeting Bay,†	201		1 840		7 940		10 690		20 470		9.0		39.0		53.0		101.0	
141	Total above mouth of Kennebec River,		6 358		39 930		44 240		26 350		110 520		6.3		6.9		4.1		17.3

* Omitting the Messalonskee and Sebasticook.
† Omitting the Cobbosseecontee.

Classification of population:
Rural, communities with less than 1 000 inhabitants.
Village, communities with between 1 000 and 4 000 inhabitants.
Urban, communities with more than 4 000 inhabitants.

TABLE No. 2. — Sewage and Manufacturing Wastes Discharged into the Kennebec and Sebasticook above the Intake of the Augusta Water Company.

Sources of Pollution.	Miles above Intake.	Persons using Public Sewers.	Persons in Mills.	Persons using Privies or Private Sewers.	Manufacturing Wastes.* Quantities Discharged Daily.							
					Woolen Mills.				Paper and Pulp Mills.			
					Spent Dye. Gals.	Preparatory Liquor. Gals.	Soap. Lbs.	Wash Water. Gals.	Ground Wood Wash. Gals.	Sulphite Wash. Gals.	Paper Machine. Gals.	Spent Sulphite Liquor. Gals.
Waterville	17.1	3 372										
Lockwood Mfg. Co.			1 300									
Riverview Worsted Co.			250		10 000		600	30 000				
Waterville Iron Works				30								
Colby University				88								
Maine Central Round House			100									
Maine Central Car Shops			295									
Chase Mfg. Co.			65		750		30					
A. P. Emery												
Hayden Brook				36								
Winslow												
Hollingsworth & Whitney Co.			650						3 000 000	2 000 000	250 000	140 000
Fairfield	20.6											
Fairfield Furniture Co.			35									
Grist Mill			4									
Electric Power Station			5									
United Box B'd & Paper Co.			13									
American Woolen Co.			175		5 000	5 000	80					
			80									
Shawmut												
United Box B'd & Paper Co.	23.8											
Lawrence Newhall & Page Co.			240						200 000			

SKOWHEGAN	34	1 516		140								
American Woolen Co.			175		10 000	10 000	340	30 000				
Marston Worsted Co.			275		6 000		75	40 000				
Com'wealth Shoe & L'th'r Co.			250									
Bowdoin Pulp Co.			10									
Skowhegan Pulp Co.			25						50 000			
Electric Light Co.			5									
Currier Brook				39								
MADISON	46	636										
Madison Woolen Co.			200		7 000		300					
Indian Spring Woolen Co.			200		5 000	5 000	150					
Great Northern Paper Co.										1 500 000	1 500 000	120 000
NORTH VASSALBORO	21.4											
American Woolen Co.			300		6 000	2 000	500					
BENTON FALLS	21.8											
United Box B'd & Paper Co.			100									
PITTSFIELD	41	1 500										
Pittsfield El. L't & Power Co.			46									
R. Dobson & Co.			300		1 500	1 500						
Waverly Woolen Co.			175		4 500	7 000	250					
Riverside Woolen Co.			110		600		125					
NEWPORT	44.5	442		4								
Newport Woolen Co.			150		5 000	5 000	250					
Weymouth Wool Co.			45									
Borden Condensed Milk Co.			30									
Total		7 466	5 608	337	61 350	35 500	2 700	100 000	3 250 000	3 500 000	1 750 000	260 000

* Data incomplete.

TABLE No. 3.—Number of Deaths from Typhoid Fever in Waterville, Me., from 1892 to 1903 by Months.

Months.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total.
January ..	0	1	0	0	0	0	1	0	0	1	0	8	11
February .	0	1	0	0	0	1	0	0	0	0	0	5	7
March	0	2	0	0	0	0	1	0	0	1	0	3	7
April	0	0	0	0	0	0	0	1	0	0	0	0	1
May	0	0	0	0	0	0	0	0	0	0	0	1	1
June	0	0	1	0	0	0	0	0	0	0	0	0	1
July	0	0	0	0	0	0	0	1	0	0	1	1	3
August ...	0	0	0	0	0	0	0	1	1	2	0	—	4*
September	1	0	0	1	0	2	0	1	0	1	2	—	8*
October ..	0	0	0	0	0	0	0	0	0	1	2	—	3*
November.	0	0	1	0	0	0	0	0	0	1	1	—	3*
December.	0	0	1	0	0	0	0	0	1	1	2	—	5*
Total...	1	4	3	1	0	3	2	4	2	8	8	18	36*

* Total for 1892 to 1902.

TABLE No. 4.—Number of Cases of Typhoid Fever in each Month from January 1, 1902, to August 1, 1903, in Waterville, Fairfield, Winslow, and Benton.

Month.	Waterville.	Fairfield.	Winslow.	Benton.	Total.
1902, January	2	0	0	0	2
February	1	1	0	0	2
March	4	0	0	0	4
April	3	0	0	0	3
May	3	0	0	0	3
June	4	0	1	0	5
July	13	1	1	0	15
August	12	1	2	1	16
September	10	1	1	0	12
October	7	3	1	0	11
November.....	20	5	2	0	27
December	64	6	14	1	85
1903, January	89	25	10	1	125
February	23	8	7	0	38
March	11	3	0	0	14
April	5	1	1	0	7
May	0	1	1	0	2
June	0	0	0	0	0
July	0	0	0	0	0
Total	271	56	41	3	371

TABLE No. 5.—Ages of Typhoid Fever Patients in Waterville, Fairfield, Winslow, and Benton, Me.

	Sex.	0–4.	5–9.	10–14.	15–19.	20–24.	25–29.	30–34.	35–39.	40–44.	45–49.	50–59.	Over 60.	Not Given.	Total.
Waterville,	Male,	4	16	23	23	27	12	9	6	2	2	3	1	3	131
	Female,	5	22	30	24	26	8	5	6	3	5	4	1	1	140
	Total,	9	38	53	47	53	20	14	12	5	7	7	2	4	271
Fairfield,	Male,	0	4	8	3	2	1	2	1	0	0	0	0	0	21
	Female,	2	6	11	3	5	1	0	2	1	0	1	3	0	35
	Total,	2	10	19	6	7	2	2	3	1	0	1	3	0	56
Winslow,	Male,	0	2	6	3	4	3	4	0	1	0	2	0	1	26
	Female,	1	2	2	2	4	1	0	0	0	0	1	1	1	15
	Total,	1	4	8	5	8	4	4	0	1	0	3	1	2	41
Benton,	Male,	0	0	1	0	0	0	0	0	0	0	0	0	0	1
	Female,	0	0	0	1	1	0	0	0	0	0	0	0	0	2
	Total,	0	0	1	1	1	0	0	0	0	0	0	0	0	3
Total,	Male,	4	22	38	29	33	16	15	7	3	2	5	1	4	179
	Female,	8	30	43	30	36	10	5	8	4	5	6	5	2	192
	Total,	12	52	81	59	69	26	20	15	7	7	11	6	6	371

TABLE No. 6.—Absence from City of the Typhoid Fever Patients during Four Weeks Previous to Illness.

	Absent.	Not Absent.	Not Stated.	Total.
Waterville	8	253	10	271
Fairfield	0	56	0	56
Winslow	0	40	1	41
Benton	0	3	0	3
Total	8*	352	11	371

* 2.2% of total cases.

TABLE No. 7. — Occupations of the Typhoid Fever Patients in Waterville, Fairfield, Winslow, and Benton.

Occupation.	Sex.	Waterville.	Fairfield.	Winslow.	Benton.	Total.
Students,	Male	31	9	3	1	44
	Female	35	12	1	1	49
	Total,	66	21	4	2	93
Mill Hands,	Male,	35	6	15	0	56
	Female,	25	1	6	0	32
	Total,	60	7	21	0	88
Housekeepers and Servants,	Female,	31	6	4	1	42
Clerks,	Male,	12	0	0	0	12
	Female,	10	1	0	0	11
	Total,	22	1	0	0	23
Car Shop Employees,	Male,	12	1	1	0	14
Laborers,	Male,	10	1	2	0	13
Professional Men,	Male,	3	0	0	0	3
Artisans,	Male,	8	0	0	0	8
	Female,	0	1	0	0	1
	Total,	8	1	0	0	9
Not Stated,	Male,	2	4	5	0	29
	Female,	3	14	4	0	57
	Total,	5	18	9	0	86
Total,	Male,	131	21	26	1	179
	Female,	140	35	15	2	192
	Total,	271	56	41	3	371

TABLE No. 8.* — RESULTS OF A HOUSE-TO-HOUSE CANVASS IN WATERVILLE, ME., WITH REFERENCE TO THE CHARACTER OF THE WATER SUPPLIES, AND THE NUMBER OF CASES OF TYPHOID FEVER.

WATER SUPPLY AT RESIDENCE.	Number of Persons.	Number of Typhoid Cases.	Morbidity Rate per 1 000.
MAINE WATER COMPANY	6 537	226	34.6
Maine Water Company and no other supply,	3 225	132	40.9
Maine Water Company and well water	866	23	26.6
Maine Water Company and spring water	2 424	71	29.3
Maine Water Company and cistern water	2	0	0.0
Maine Water Company, spring water, and well water	20	0	0.0
Maine Water Company and well, spring, or cistern water	3 312	94	28.4
SUPPLIES OTHER THAN MAINE WATER COMPANY	1 459	21	14.4
Well water only	1 286	19	14.8
Well water and spring water	25	1	40.0
Well water and cistern water	13	0	0.0
Spring water only	108	1	9.3
Spring water and cistern water	23	0	0.0
Cistern water only	4	0	0.0
Total	7 996	247	30.9

* Similar tables were made for Winslow, Fairfield, and Benton.

TABLE No. 9. — SUMMARY OF A HOUSE-TO-HOUSE CANVASS IN THE KENNEBEC WATER DISTRICT, WITH REFERENCE TO THE CHARACTER OF THE WATER SUPPLIES AND THE NUMBER OF CASES OF TYPHOID FEVER.

	SUPPLY FROM MAINE WATER COMPANY.			NO SUPPLY FROM MAINE WATER COMPANY.			TOTAL.		
	Number of Persons.	Number of Typhoid Cases.	Morbidity Rate per 1 000.	Number of Persons.	Number of Typhoid Cases.	Morbidity Rate per 1 000.	Number of Persons.	Number of Typhoid Cases.	Morbidity Rate per 1 000.
Waterville	6 537	226	34.57	1 459	21	14.41	7 996	247	30.9
Fairfield	1 614	54	33.45	468	2	4.25	2 082	56	26.9
Winslow	244	11	45.08	902	19	21.06	1 146	30	26.2
				(470)*	(4)*	(8.29)*			
Benton	152	2	13.15	125	1	8.00	277	3	10.8
Total	8 547	293	34.28	2 954	43	14.55	11 501	336	29.2

* Omitting users of Kennebec River water.

TABLE No. 10.—Statistics of Population and Typhoid Fever for Augusta, Me., from 1865 to 1903. (From Records in the City Clerk's Office.)

Year.	Population Estimated.	Deaths.		Death Rate per 100 000.		Typhoid per cent. of Total Deaths.
		Total.	Typhoid.	Total.	Typhoid.	
1865	7 650	90	12	1 176.0	156.9	13.3
1866	7 675	26	1	338.8	130.0	3.9
1867	7 700	3	0	39.0	0.0	0.0
1868	7 750	1	0	12.9	0.0	0.0
1869	7 800	50	3	641.0	38.5	6.0
1870	7 808	99	4	1 268.0	51.2	4.1
1871	7 875	90	2	1 143.0	25.40	2.2
1872	7 925	95	6	1 198.0	75.7	6.3
1873	8 000	138	4	1 725.0	50.0	2.9
1874	8 075	80	0	991.0	0.0	0.0
1875	8 150	90	0	1 104.0	0.0	0.0
1876	8 225	131	6	1 584.0	73.0	4.6
1877	8 300	125	6	1 505.0	72.3	4.8
1878	8 425	128	6	1 520.0	71.2	4.7
1879	8 550	101	1	1 182.0	11.7	0.99
1880	8 445	115	0	1 327.0	0.0	0.0
1881	8 665	131	4	1 485.0	45.3	3.1
1882	9 000	102	1	1 134.0	11.1	0.98
1883	9 175	127	2	1 384.0	21.8	1.6
1884	9 400	80	0	851.0	0.0	0.0
1885	9 575	100	1	1 044.0	10.4	1.0
1886	9 775	143	6	1 462.0	61.4	4.2
1887	9 995	170	8	1 704.0	80.2	4.7
1888	10 175	151	4	1 484.0	39.3	2.7
1889	10 350	139	2	1 343.0	19.3	1.4
1890	10 527	182	16	1 729.0	152.0	8.8
1891	10 675	34	5	318.0	46.9	14.7
1892	10 825	315	7	2 910.0	64.7	2.2
1893	10 950	304	9	2 776.0	82.2	3.0
1894	11 075	322	6	2 906.0	54.2	1.9
1895	11 200	322	7	2 874.0	62.5	2.2
1896	11 325	316	11	2 790.0	97.1	3.5
1897	11 425	323	7	2 825.0	61.2	2.2
1898	11 525	257	20	2 230.0	173.5	7.8
1899	11 625	318	9	2 734.0	77.4	2.8
1900	11 683	289	4	2 472.0	34.2	1.4
1901	11 800	312	11	2 644.0	93.2	3.5
1902	11 875	304	6	2 560.0	50.3	2.0
1903	11 975	297	31	2 480.0	25.9	10.4

TABLE No. 11.—Typhoid Fever Deaths in Augusta, Me. By Months from 1865 to 1903.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1865	0	0	0	1	0	0	0	4	3	4	0	0
1866	1	0	0	0	0	0	0	0	0	0	0	0
1867	0	0	0	0	0	0	0	0	0	0	0	0
1868	0	0	0	0	0	0	0	0	0	0	0	0
1869	0	0	1	0	0	0	0	1	0	1	0	0
1870	0	0	0	0	0	0	1	1	0	2	0	0
1871	0	0	0	0	0	0	0	0	1	0	1	0
1872	0	0	0	0	0	1	0	0	1	3	1	0
1873	0	0	0	0	0	0	1	0	2	0	0	1
1874	0	0	0	0	0	0	0	0	0	0	0	0
1875	0	0	0	0	0	0	0	0	0	0	0	0
1876	0	0	0	0	1	2	1	0	1	0	1	0
1877	0	0	0	0	0	0	0	2	0	4	0	0
1878	0	0	0	0	0	0	1	0	0	2	0	3
1879	1	0	0	0	0	0	0	0	0	0	0	0
1880	0	0	0	0	0	0	0	0	0	0	0	0
1881	0	0	0	0	0	1	0	0	0	2	1	0
1882	0	0	1	0	0	0	0	0	0	0	0	0
1883	0	0	1	0	0	0	0	0	0	1	0	0
1884	0	0	0	0	0	0	0	0	0	0	0	0
1885	0	0	0	0	0	0	1	0	0	0	0	0
1886	0	0	1	0	1	0	0	1	0	1	2	0
1887	0	0	0	0	1	0	0	1	3	3	0	0
1888	1	1	0	0	0	0	0	0	0	2	0	0
1889	0	0	0	1	0	0	0	0	0	1	0	0
1890	2	0	0	1	0	1	2	1	3	1	1	4
1891	0	4	1	0	0	0	0	0	0	0	1	0
1892	0	0	1	1	1	0	0	0	0	1	1	2
1893	1	1	5	0	0	0	0	0	0	1	1	0
1894	1	1	2	0	0	0	0	0	0	0	1	2
1895	0	2	1	0	0	0	0	0	0	1	0	3
1896	0	3	0	3	1	0	0	0	0	1	1	2
1897	0	0	4	1	1	0	0	0	0	0	0	1
1898	0	2	1	1	1	0	0	0	10	3	1	1
1899	1	2	0	1	0	1	0	0	0	1	2	1
1900	0	0	0	0	0	0	0	0	2	0	0	2
1901	1	1	2	2	1	1	0	0	0	0	2	1
1902	1	0	1	0	0	1	1	0	0	1	0	1
1903	7	8	10	4	1	0	1	0	0	0	0	0

TABLE No. 12. — Chronological Table of Typhoid Cases and Deaths in Augusta between October 1, 1902, and May 1, 1903.

Date.	October.	November.	December.	January.	February.	March.	April.
1	0	0	1	3	5+1*	1+1*+1†	2
2	0	2+1†	1	2+1*	1	2+1*	2+1*
3	0	0	1	3	1	2+1*	0
4	0	0	1	0	1+1*+1†	1	1
5	0	0	1+1*	1*	5+2*	2	0
6	0	0	2+1†	2	4+3*	1	0
7	0	0	0	1	3	2+1*	0
8	0	0	0	0	5+1*	1	0
9	0	0	1	2	4+1*	4	1
10	0	0	1	1	2	1	0
11	0	0	2	0	2	0	0
12	0	0	2	4	3+1*	3	0
13	0	0	1	0	1	0	0
14	0	1	1	3	5+1*	2	0
15	0	1	0	3	1	0	0
16	0	1	1	2	3+1*	1	0
17	0	0	1	6+3*	3	1	2
18	0	0	1*	3	6+1*	1	0
19	0	0	1	3	1†	0	0
20	0	0	1	2	11+1*	1+1*	0
21	1*	1	2	0	5+1*	0	0
22	0	1	3	5+1*	2	1	0
23	0	0	1*	3	2	3	0
24	0	1	1	2+1*	4	1	0
25	0	3	0	6	3	0	0
26	0	2	1	2	2	1	1
27	0	0	0	1	0	2	1
28	0	0	0	2	3	1	0
29	1	1*	3	2	0	0	0
30	0	0	1	2	0	1	0
31	0	0	1	0	0	1	0
Totals	2–1*	15–1*	35–3*	72–7*	104–15*	43–5*	11–1*

* Indicates deaths. † Indicates date of case is uncertain.

Total for epidemic of 1902–1903, 280, November 1, 1902, to May 1, 1903.

TABLE No. 13. — Seasonal Distribution of Typhoid Fever in Augusta, Me., before and after the Introduction of Kennebec River Water. (Compiled from Records in the City Clerk's Office.)

	Period.	Average Population.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Number of Deaths	1865–1887	8 200	2	0	4	1	3	4	5	10	11	23	6	4
	1888–1903	11 300	15	25	28	15	6	4	4	1	15	13	9	20
Death Rate per 100 000	1865–1887	8 200	1.06	0	2.12	0.53	1.59	2.12	2.65	5.30	5.83	12.21	3.18	2.12
	1888–1903	11 300	8.32	13.80	15.50	8.87	3.33	2.20	2.20	0.55	8.32	7.18	4.98	11.07

TABLE No. 14. — Showing Distribution of Typhoid in Augusta, Me., by Ages and Sex, January 1, 1902, to January 1, 1904.

Age.	Cases.		Deaths.	
	Male.	Female.	Male.	Female.
0 — 4	7	6	1	2
5 — 9	21	20	1	0
10 — 14	25	28	0	2
15 — 19	31	26	4	3
20 — 24	30	33	3	1
25 — 29	27	20	2	2
30 — 34	7	3	3	0
35 — 39	8	12	0	4
40 — 44	7	7	1	1
45 — 49	3	7	1	1
50 — 54	2	2	0	0
55 — 59	1	1	1	0
60 — 64	0	0	0	0
65 — 69	1	0	1	0
70 and up	1	0	0	0
Total	171	165	18	16

Total cases, 336; total deaths, 34.

TABLE No. 15. — Showing Distribution of Typhoid in Augusta, Me., by Occupation, January 1, 1902, to January 1, 1904.

Occupation.	Male.	Female.	Total.
Students	43	50	93
Mill hands	25	28	53
Clerks	15	11	26
Laborers	24	2	26
Artisans	28	3	31
Professional men	4	7	11
Railroad employees	4	0	4
Business men	5	0	5
Lunatics	2	0	2
Children	12	11	23
Servants	2	5	7
Housekeepers	0	23	23
Not stated	8	24	32
Total	172	164	336

TABLE No. 16. — Statistics of Disinfection of Stools, and Absence from City during Month previous to Sickness. Compiled for Typhoid Cases from January 1, 1902, to January 1, 1904, Augusta, Me.

Disinfection of Stools.

Number of Cases.		
Stool Disinfected.	Stools not Disinfected.	Not Stated.
262	48	26

Absence from City.

Number of Cases.		
Not Absent.	Absent.	Not Stated.
308	22	6

TABLE No. 17. — WATER CANVASS. TABLES SHOWING THE DISTRIBUTION OF TYPHOID FEVER IN THE CITY OF AUGUSTA ACCORDING TO WATER SERVICE IN 1903.

JANUARY 1, 1902, TO JANUARY 1, 1904.

WATER SUPPLY USED.	Number of Persons.	Typhoid Cases.	Typhoid Deaths.	Morbidity per 1 000.
River only	2 980	160	16	53.7
Devine only	408	5	1	12.3
Wells, springs, and cisterns	1 441	34	5	23.6
River and Devine	295	7	2	23.7
River and wells, springs, and cisterns	3 671	105	6	28.6
Devine and springs or cisterns	39	0	0	0
Unclassified	12	0	0	0
Total	8 846	311	30	35.2

DURING THE EPIDEMIC, NOVEMBER 1, 1902, TO MAY 1, 1903.

WATER SUPPLY USED.	Number of Persons.	Typhoid Cases.	Typhoid Deaths.	Morbidity per 1 000.
River only	2 980	134	15	45.0
Devine only	408	3	1	7.3
Wells, springs, and cisterns	1 441	28	5	19.4
River and Devine	295	7	2	23.7
River and wells, springs, and cisterns	3 671	88	6	24.0
Devine and springs or cisterns	39	0	0	0
Unclassified	12	0	0	0
Total	8 846	260	29	29.4

TABLE No. 18. — POPULATIONS, NUMBER OF DEATHS FROM TYPHOID FEVER, AND THE AVERAGE TYPHOID FEVER DEATH RATES FOR CITIES AND TOWNS IN THE STATE OF MAINE WHICH HAVE MORE THAN 4 000 INHABITANTS, FROM 1892 TO 1903. COMPILED FROM THE PUBLIC REPORTS OF THE STATE BOARD OF HEALTH.

County.	City or Town.	Population.		Number of Typhoid Deaths Each Year.												Total No. of Typhoid Deaths.	Average Death Rate per 100 000
		1890.	1900.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.		
Kennebec,	Augusta,	10 527	11 683	9	7	6	5	5	5	19	8	4	9	4	29	110	79
York,	Saco,	6 075	6 122	4	1	1	6	9	3	3	4	6	5	4	5	51	70
York,	Biddeford,	14 443	16 145	18	5	4	12	17	8	6	5	16	19	10	8	128	66
Androscoggin,	Lewiston,	21 701	23 761	36	13	21	9	11	14	17	24	15	13	2	3	178	62
Penobscot,	Bangor,	19 103	21 850	21	12	25	13	8	8	7	15	4	24	7	10	154	59
York,	Sanford,	4 201	6 078	1	4	1	1	2	2	1	3	1	0	17	9	42	58
Cumberland,	Brunswick,	6 012	6 806	15	9	7	6	0	0	1	2	1	2	0	3	46	57
Penobscot,	Oldtown,	5 312	5 763	4	1	3	2	2	1	3	2	3	7	0	9	37	53
Aroostook,	Caribou,	4 087	4 758	1	1	6	2	5	0	3	3	4	2	1	0	28	49
Hancock,	Ellsworth,	4 804	4 297	1	2	4	0	2	5	3	0	2	0	2	2	23	45
Kennebec,	Waterville,	7 107	9 477	2	3	3	1	0	3	2	3	2	7	7	17	50	44
Penobscot,	Brewer,	4 193	4 835	0	3	6	0	2	1	0	4	1	7	1	0	25	43
Washington,	Calais,	7 290	7 655	0	9	5	0	7	0	0	4	2	3	3	2	35	38
Aroostook,	Ft. Fairfield,	3 526	4 181	2	0	2	9	2	0	0	2	0	0	0	0	17	34
Cumberland,	Portland,	36 425	50 145	6	14	20	21	12	11	36	13	19	15	15	17	199	33
Aroostook,	Houlton,	4 015	4 686	0	3	1	1	1	1	0	3	2	0	2	3	17	30
Cumberland,	Westbrook,	6 632	7 283	1	3	2	3	2	0	4	2	1	1	2	3	24	27
Washington,	Eastport,	4 908	5 311	0	2	2	3	0	1	3	1	0	2	1	1	16	25
Cumberland,	S. Portland,		6 287				0	3	5	0	2	0	0	1	3	14	25
Hancock,	Eden,	1 946	4 379	1	1	0	0	1	2	0	2	3	0	1	0	11	21
Androscoggin,	Auburn,	11 250	12 951	3	6	3	1	5	1	3	5	4	0	1	1	33	21
Kennebec,	Gardiner,	5 491	5 501	0	2	0	0	1	2	2	2	1	2	1	1	14	21
Knox,	Rockland,	8 174	8 150	3	4	0	2	0	1	5	1	1	1	1	1	20	20
Somerset,	Belfast,	5 294	4 615	1	3	0	1	1	0	1	1	0	0	0	1	9	17
Sagadahoc,	Bath,	8 723	10 477	2	3	2	1	2	0	1	0	1	1	2	1	16	13
Somerset,	Skowhegan,	5 068	5 180	2	1	1	2	0	0	0	1	0	0	0	0	7	11

TABLE No. 19.—Populations, Number of Deaths from Typhoid Fever, and the Average Typhoid Fever Death Rates for Cities and Towns in the State of Maine which have between 2 000 and 4 000 Inhabitants, from 1892 to 1903.

County.	City or Town.	Population.		Number of Typhoid Deaths in Each Year.												Total No. of Typhoid Deaths.	Average Death Rate per 100 000.
		1890.	1900.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.		
Oxford,	Rumford,	898	3 770	2	5	0	1	2	1	2	1	3	3	5	3	28	62
Kennebec,	Winslow,	1 814	2 277	2	3	0	0	0	3	0	1	0	0	2	5	16	59
Penobscot,	Hampden,	2 484	2 182	1	1	1	3	0	0	1	1	3	1	0	0	12	46
Kennebec,	Hallowell,	3 181	2 714	0	1	2	1	2	1	1	0	0	4	2	1	15	46
Androscoggin,	Lisbon,	3 120	3 603	3	6	1	0	1	0	1	6	1	0	0	0	19	44
York,	Kittery,	2 864	2 878	4	0	3	0	0	0	0	0	1	3	2	2	15	44
Somerset,	Pittsfield,	2 503	2 891	0	0	1	3	2	0	2	3	1	1	1	1	15	43
Penobscot,	Orono,	2 790	3 257	2	3	1	1	1	0	0	0	0	2	5	1	16	41
York,	So. Berwick,	3 434	3 188	2	1	1	2	4	0	2	1	0	0	2	0	15	39
Franklin,	Jay,	1 541	2 758	1	0	0	4	1	1	1	1	1	0	0	1	11	33
Franklin,	Farmington,	3 207	3 288	0	3	2	3	1	1	1	1	0	0	0	1	13	33
Hancock,	Bucksport,	2 921	2 339	1	3	2	0	0	0	1	0	0	1	1	0	9	32
Aroostook,	Presque Isle,	3 046	3 804	6	4	2	1	0	0	0	0	1	2	1	0	17	31
Sagadahoc,	Richmond,	3 082	2 049	1	0	2	0	0	0	1	0	2	1	1	1	9	31
Hancock,	Deer Isle,	3 422	2 047	2	1	3	1	0	1	0	0	0	0	0	1	9	31
Aroostook,	Fort Kent,	1 826	2 528	0	0	0	0	2	0	0	4	0	0	1	1	9	30
Somerset,	Fairfield,	3 510	3 878	0	2	1	0	0	2	0	1	0	1	1	6	14	30
Kennebec,	Vassalboro,	2 052	2 062	0	0	0	2	2	0	0	0	1	0	2	1	8	28
Androscoggin,	E. Livermore,	1 506	2 129	0	4	0	0	0	2	0	1	0	0	0	0	7	28
Oxford,	Paris,	3 156	3 225	3	0	0	0	1	2	0	1	2	1	0	0	10	26
York,	Berwick,	2 294	2 280	1	0	0	1	1	0	1	0	2	0	1	0	7	26
Washington,	Lubec,	2 069	3 005	0	0	3	2	0	0	0	2	2	0	0	0	9	25
York,	Wells,	2 029	2 007	2	1	0	0	0	0	1	0	0	1	0	1	6	25
Knox,	Thomaston,	3 009	2 688	1	2	1	0	2	0	0	0	0	0	2	0	8	25
York,	Kenneb'kp't,	2 196	2 123	1	0	1	1	0	0	0	0	0	1	0	1	6	24
Lincoln,	Waldoboro,	3 505	3 143	0	0	1	0	0	2	1	0	1	1	1	2	9	24
Lincoln,	Bristol,	2 821	2 572	1	0	0	2	0	1	1	1	0	1	0	0	7	23
Knox,	Rockport,	2 150	2 314	0	0	0	0	0	1	1	1	2	0	1	1	6	22
York,	Kennebunk,	3 172	3 228	0	1	3	1	1	0	2	0	1	0	0	0	8	21
Washington,	Jonesport,	1 917	2 124	0	0	1	2	0	0	0	0	1	1	0	0	5	20
Penobscot,	Dexter,	2 732	2 941	2	0	2	1	0	0	1	0	1	1	0	0	7	20
Cumberland,	Gorham,	2 888	2 540	0	0	0	0	1	1	2	0	1	0	0	1	6	20
Sagadahoc,	Topsham,	1 394	2 097	1	1	0	0	1	0	1	0	0	0	0	0	4	16
Somerset,	Madison,	1 815	2 764	1	1	1	0	0	0	0	0	1	1	0	0	5	15
Kennebec,	Winthrop,	2 111	2 088	0	1	0	0	0	0	0	1	0	0	1	1	4	16
Knox,	Warren,	2 037	2 069	0	1	0	1	0	0	1	0	0	0	0	1	3	12
Knox,	Camden,	2 471	2 825	0	0	0	0	0	0	0	0	0	2	1	1	4	12
Oxford,	Norway,	2 665	2 902	0	1	1	0	0	1	1	0	0	0	0	0	4	11
Cumberland,	Freeport,	2 482	2 339	1	1	0	0	0	1	0	0	0	0	0	0	3	11
Cumberland,	Yarmouth,	2 098	2 274	0	1	1	0	0	0	0	0	0	0	0	1	3	11
Cumberland,	Bridgton,	2 605	2 868	1	0	1	0	1	0	0	0	0	0	0	0	3	9
Knox,	St. George,	2 491	2 206	0	0	0	0	0	0	1	0	1	0	0	0	2	8
Knox,	Vinalhaven,	2 617	2 358	0	0	0	1	0	0	0	1	0	0	0	0	2	7
Kennebec,	Chelsea,	2 356	3 092	0	0	1	0	0	0	1	0	0	0	0	0	2	5
Hancock,	Tremont,	2 036	2 010	0	0	0	0	0	1	0	0	0	0	0	0	1	4
Washington,	Machias,	2 035	2 082	0	0	0	0	0	0	0	0	1	0	0	0	1	4
York,	York,	2 444	2 668	0	0	0	0	0	0	0	0	0	1	0	0	1	4

DISCUSSION.

MR. CHARLES G. HYDE. I want to express my appreciation and thanks to the gentlemen who prepared the paper just read. The investigations carried on by them were thorough and eminently scientific. I am very glad that such an excellent report of this study has been presented to this Association, so that it can be published. I do not believe that many of us realize the great educational value that these papers have as they go out among sanitarians, engineers, and water-works men generally.

Every year adds to our knowledge (a vast amount having been already accumulated) of the intimate association between the quality of the water supply and the health of the communities supplied. You in Massachusetts are very fortunate in having a state board of health, the pioneer in all this work, which has been able to study the quality of the water supplies of this state for a very long time, so that there is hardly a supply whose character is not now known. Those of you who live in this commonwealth are able to know how comparatively safe you are in taking a glass of water.

I am less fortunate than many of you in that I am living in a state where very little public attention is paid to the quality of the water. I have been living in Pennsylvania for the last four years, and since residing in Harrisburg, I think I have not taken a glass of raw water at any time. All water used for drinking in our house has to be first filtered and then boiled, and even then we have some difficulty in getting good results, because the water is so very bad to start with. Until I went to Harrisburg nothing at all was known in regard to the quality of the Susquehanna River water. It is the largest stream entering the Atlantic Ocean between the Gulf of St. Lawrence and the Gulf of Mexico; notwithstanding that fact, however, I believe very few analyses of the water have been made either in New York or Pennsylvania or to the south. In taking up the question of the purification of the water supply of Harrisburg, it was necessary to start at the beginning and install a laboratory to discover what the real character of the water was, and to equip an experimental purification plant to see how it could best be improved. That

work has been done. No paper embodying the results of the investigations has been as yet published, but I hope one may be soon.

The typhoid fever death rate in communities along the Susquehanna River, where the unpurified water is used, is high; it has been continuously high for a great many years, and is likely to be so in the future, because very few of these towns, except Harrisburg and one or two others, are considering the quality of the water which they use for drinking.

A great deal of information has been gathered in regard to the immediate relation between the quality of drinking water and the health of communities. Dr. Sedgwick, for instance, in his recent Lowell Institute course of lectures, has shown how the health of the city of Lawrence has been improved — not only as regards typhoid fever, but in general — by the filtering of the public water supply. These same facts were exhibited by Mr. Morris Knowles and myself in a paper presented two or three years ago to the American Society of Civil Engineers in New York. The results are really marvellous, and they simply show how important this question is. A study of the effect of the Albany filters upon the typhoid fever and the general death rate in that city reveals the same most satisfactory results. And I have reason to believe that the data collected with regard to this point in many other places present the same features.

There is just one thing more that I should like to say, and that is, that I think water-works officials and engineers should act in harmony with the officials of health boards, not only the state boards in the several commonwealths, but the local boards of health. I think every one of us should look forward to the time when infectious diseases of every nature, and especially those which are water borne, shall be accurately, systematically, and thoroughly reported, and the records carefully studied by the public at large, so that these epidemics which have been such an enormous drain, not only upon the health but upon resources of the communities in which they have occurred, shall be avoided, and we shall truly live in an era of very much better health.

Mr. Charles-Edward A. Winslow. Truth is said to be

at the bottom of a well. I suppose for that reason it is natural that when you get to the bottom of any water-works proposition you find some pretty big fundamental truths.

It seems to me that in this discussion to-day we have been getting down to some principles which have a much wider application than to the matter of water supply alone. In the course of lectures to which Mr. Hyde just referred, Professor Sedgwick said a word or two in regard to the extension of public powers in its bearing on public health. Now this question of public ownership, or Socialism, is perhaps the most important political question that we have to face in the next twenty years. Professor Sedgwick said that there are always a great many people who say, "It is a good thing to have gone as far as we have gone, but we do not want to go any farther," and he pointed out that that is not the way the world works; if it sets out on a certain path it is likely to keep going on. I think we have all, as citizens, to meet the probability that Socialism, merely defined as the extension of the power of the state, is going to increase, and it is very necessary that we should see that it increases along sound and wise lines.

In Massachusetts we are pretty familiar with extreme Socialism in the matter of water-works control. In other states the problem is being met in different ways, sometimes, as has been stated, by contracts with water companies. In Louisville they have met it by the city gradually acquiring the stock of the water company, which I think is held by the sinking fund commissioners, just as any other city property is held. And we have heard to-day of a new and an extremely interesting and important method of gaining control by the municipality.

Professor Smith has brought out the point that the administration of the private company is often admirable, better than that of the municipality. But isn't this so largely because those water companies know that if they do not come very sharply up to the mark, the city will step in and take their franchises? So that even in those cases we can say that the good quality of the water supply is due to the potential control of the city. Is not that a good general principle, that as long as private companies perform public functions well and cheaply, they may continue to do so,

and as soon as they cease to do this, the public must step in and take control?

When this happens I submit that the two admirable papers we have heard read to-day furnish valuable precedents as to the way in which the public should proceed.

The extension of the power of the state should not be made rashly or unadvisedly; but when it is made, as in the case of these Maine water districts, by a strictly legal method and after the most thorough investigation by competent experts, the socialization of public utilities may be one of the most efficient aids to social progress.

MR. LANGDON PEARSE* (by letter). In this paper Messrs. Whipple and Levy have succinctly stated the main points of the recent typhoid epidemic in the Kennebec River valley. The writer, however, would like to add a few notes of interest, as he was the resident sanitary engineer for Mr. Whipple at Augusta.

The two principal towns above Fairfield, on the Kennebec, are Skowhegan and Madison. Both towns are partly sewered into the Kennebec. They are supplied with a water which seems fairly safe at present. Skowhegan is supplied by several aqueducts from springs and by water pumped from a pond below the town. At times of drought this supply is re-inforced by pumping river water. Madison draws its supply from the Kennebec above the dam below which its sewage is discharged. Above Madison there is no town which discharges sewers into the Kennebec.

In order to supplement the published typhoid records, the writer, in the course of an inspection trip, interviewed a number of physicians in both Madison and Skowhegan, and found that the typhoid occurred only in scattering cases, and then, as a rule, in the spring and fall, the normal season for typhoid.

On the Sebasticook, a tributary of the Kennebec, the two towns with sewers are Pittsfield and Newport. Pittsfield derives its water supply from the west branch of the Sebasticook, Newport from a pond. In neither town has there been much typhoid. Most of the cases have occurred in the spring and fall, though in Pittsfield there are more in the winter than in Newport. So

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far as I could ascertain, none of these towns had ever suffered from a typhoid epidemic. This information, in connection with the low typhoid death rate at Hallowell and Gardiner, and the few cases there traceable, shows the comparative immunity from typhoid enjoyed by those communities in the Kennebec valley which use a water supply unlikely to be infected or polluted. It also gives another reason why it is probable that the direct source of the past typhoid epidemics at Augusta has been the sewage of Oakland and Waterville.

In the following table I have shown the annual typhoid deaths (taken from the reports of the Maine State Board of Health) and the average typhoid death rate for the principal towns on the Kennebec watershed. This table is, I think, self-explanatory. I would call attention to the fact that many of the deaths noted for Madison, Skowhegan, Pittsfield, and Newport did not occur at the same season as those in Waterville or Augusta.

TABLE No. 20.

DEATHS FROM TYPHOID FEVER IN THE PRINCIPAL TOWNS IN THE KENNEBEC VALLEY 1892–1903.

TOWN.	POPULATION, U. S. CENSUS.		DEATHS FROM TYPHOID FEVER DURING THE YEAR											Total Number of Typhoid Deaths.	Average Typhoid Death Rate per 100 000.	Deaths in 1903. *
	1890.	1900.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.			
Madison	1 815	2 764	1	1	1	0	0	0	0	0	1	1	0	5	21	1
Skowhegan	5 068	5 180	2	1	1	2	0	0	0	1	0	0	0	7	12	1
Fairfield	3 510	3 878	0	2	1	0	0	2	0	1	0	1	1	8	19	
Oakland	2 044	1 913	2	0	1	0	0	2	1	0	0	2	0	8	37	
Newport	1 188	1 533	0	0	2	0	0	1	0	0	1	0	0	4	26	1
Pittsfield	2 503	2 891	0	0	1	3	2	0	2	3	1	1	1	14	48	1
Waterville	7 107	9 477	2	3	3	1	0	3	2	3	2	7	7	33	35	18
Augusta	10 527	11 683	9	7	6	5	5	5	19	8	4	9	4	81	66	31
Hallowell	3 181	2 714	0	1	2	1	2	1	1	0	0	4	2	14	45	1
Gardiner	5 491	5 501	0	2	0	0	1	2	2	2	1	2	1	13	22	1
Richmond	3 082	2 049	1	0	2	0	0	0	1	0	2	1	1	8	28	2

* NOTE. — These figures were compiled from the records of the city clerks, and are not official.

As a water supply for Augusta, the Kennebec, unfiltered, should have been condemned long ago, not only on account of the typhoid

epidemics directly traceable to the use of the water, but also on account of the evident pollution of the stream above Augusta. From Madison down, sewage and mill wastes pour into the river. At Waterville alone, only 17.1 miles above the intake at Augusta, the so-called "great sewer" of Waterville discharges continuously into the tail-race of the Lockwood Mills. (The sewerage system of Waterville has been gradually enlarged since its beginning in 1889, two years after the installation of the Augusta Water Company.) For three miles down stream, the fecal matter preserves its integrity, and for a longer distance toilet paper may be traced. Samples of the river-bed were dredged up at intervals, all of which, except those taken at the intake and a mile above, underwent a strong putrefaction in the course of seven weeks. When freshly taken, the sewage odor could be traced for seven miles below Waterville. Most of these samples were black slime, either scraped off a rocky bottom or brought up with sand or gravel.

At Augusta, as Mr. Whipple says, the possibilities of infection by media other than water were one by one excluded from consideration. In studying the distribution of the cases among the milk dealers it was found that one dealer, a Frenchman, had served thirty-three persons who were attacked with typhoid, while the highest number served by an American was ten. This apparent bunching of cases with one milkman was explained by the remarkable prevalence of typhoid among the French Canadians, his chief customers. In addition the cases were very evenly distributed over a period of two months. So far as I could ascertain, none of the milk dealers had a case of typhoid in their families or among their help, either before or during the epidemic.

In both Waterville and Augusta, there are large numbers of French Canadians, many of whom are employed in the mills. Some of them are so ignorant of sanitation that they do not distinguish between the functions of a urinal and a watercloset. An inspection of their homes and surroundings reveals as discouraging a situation. Many use privies which are as dangerous to the user as they are to the consumer of the water from the watershed. While this may be partly due to the negligence of the owners of the property, it is usually caused by the carelessness

of the tenants. Filthy back-yards and reeking pigsties and chicken coops drain directly into the stream. A striking example of the ease with which the Kennebec may be polluted was seen at Waterville. Several privies used by some thirty people were situated about thirty-five feet from low water, but well below high-water mark. The boxes were loosely joined, leaching on the ground. A French Canadian who was dawdling around noticed my interest in the privies and volunteered the remark that he had been greatly inconvenienced last spring because he had to clean out those privies. Usually he simply built a new set to replace the old which the spring freshet swept away bodily with the accumulation of filth for a year.

A study of the maps of both Waterville and Augusta, on which the typhoid cases were plotted, shows that a large percentage of the cases occurred among the poorer classes, particularly among these same French Canadians. For instance, in one family of eleven French Canadians, at Augusta, nine were sick with typhoid within two months. All had drunk river water. Probably some caught the disease from the earlier patients, for a survey of the premises a year later showed an unclean privy and an unkempt yard. Such general conditions as I have described do not detract from the virulence of the epidemic. They emphasize, however, a means to restrict the spread of epidemics which increase gradually, namely, by an efficient sanitary police who can not only instruct the people in cleanliness, but are empowered to force them to observe the elementary principles of sanitary science.

In conclusion, the writer would like to acknowledge the various courtesies afforded him by the officials of the Augusta Water District and the doctors of Augusta. Then, too, the uniform alacrity with which the people of Augusta furnished information materially lightened the labor of the extended investigation laid out by Mr. Whipple.

MR. R. WINTHROP PRATT* (by letter). By way of discussing the paper of Messrs. Whipple and Levy, I should like to submit a brief account of the severe typhoid epidemic which occurred at Columbus, Ohio, in the early part of 1904.

* Engineer to the Ohio State Board of Health, Columbus, Ohio.

The population of Columbus at the time of the epidemic was about 150 000. Besides this resident population, there were present in the city a large number of visitors, due in part to the opening of the state legislature.

TABLE No. 21.

MONTHLY RECORD OF TYPHOID FEVER CASES AND DEATHS IN COLUMBUS, O.

Month.	Typhoid Cases Reported.	Deaths from Typhoid.			Death Rate per 100 000 per Year (based on resident deaths).	Death Rate per 100 000 per Year (based on total deaths).
		Residents.	Non-Residents.	Total.		
Dec., 1903	40			4		32
Jan., 1904	725	28	7	35	224	280
Feb., 1904	798	86	8	94	688	752
March, 1904	83	28	5	33	224	264
April, 1904	28	7	2	9	56	72

DAILY RECORD OF CASES.

1904.				1904.			
	Jan.	Feb.	March		Jan.	Feb.	March
1	1	138	9	17	2	19	2
2	0	52	4	18	24	25	2
3	0	29	1	19	48	22	1
4	1	28	4	20	24	27	0
5	8	28	5	21	44	4	4
6	3	48	3	22	35	21	0
7	3	16	7	23	41	8	0
8	7	74	2	24	16	15	0
9	4	34	1	25	43	19	2
10	1	26	3	26	25	14	4
11	5	19	5	27	48	5	0
12	9	15	2	28	35	2	2
13	26	36	1	29	47	4	2
14	34	12	2	30	81		2
15	43	36	2	31	23		1
16	47	13	4				

The typhoid death rate for years previous to this epidemic had never been as great as that of many other cities. Sources of pollution to the water supply were, however, known to exist.

The death rate among the transient population was probably greater than that among the resident population; and furthermore there were many persons who contracted typhoid in Colum-

bus at this time and died elsewhere, their deaths not being included in the above table. This shows that the visitors to a city like Columbus, having a water supply subject to pollution, are more likely to be affected than are the residents. This is, probably, because the latter are in the habit of taking certain precautions in using the water while the former come to the city and use it carelessly or unsuspectingly. When the epidemic is fully under way, however, and the fact is known all over the country, then the visitors, or at least those with ordinary intelligence, are probably quite as careful about using the water as the residents.

Columbus is supplied with water from the following sources: *First*, the Scioto River; *second*, Filter Gallery on the bank of the Scioto River; *third*, Alum Creek, and *fourth*, wells driven along the bank of Alum Creek.

At the " West Side Pumping Station " water is pumped from the first two sources and supplied to the central or business part of the city as well as to the western and northern portions. About 11 000 000 gallons per day are supplied by this pumping station, and the proportion drawn from the river directly depends upon the quantity available from the filter gallery. The latter is used when possible but is never able to furnish enough water for any considerable time, so that the raw river water is almost always being pumped into the mains in greater or less amount. Just previous to the epidemic 3 000 000 to 4 000 000 gallons per day, out of the 11 000 000 pumped at the West Side Station, was raw river water.

At the " East Side Pumping Station " water from Alum Creek or from driven wells near by, depending upon the quantity available from the latter, is supplied to the eastern portion of the city. The quantity from this source is perhaps 75 per cent. of that furnished by the West Side Station.

Almost without exception the typhoid fever cases occurred among the residents of the district supplied with Scioto River water or among the business men who, though residing outside of this district, were supplied with Scioto River water at their offices. This fact proved that the water supply was the cause of the trouble and also showed that the Scioto River rather than Alum Creek was infected.

The watershed of the Scioto River above Columbus covers an area of 1 070 square miles and consists principally of farm land, although several communities, constituting serious sources of pollution to the river water, are located upon it.

Within 65 miles of Columbus, 27 towns and 4 institutions exist upon the river or its tributaries, representing a population of about 43 000, while the sewers of six of the towns and three of the institutions, representing a population of about 30 000, discharge directly into the river or its tributaries.

Although there are many places which might have infected the river water with typhoid bacilli, investigation has shown that by far the most probable cause of the epidemic was the State Hospital for Insane, one of the institutions referred to above, located within the city limits of Columbus.

The sewerage system at this hospital is rather unusual. The domestic sewage from the institution, which is occupied by some 1 600 people, is collected in an 8-inch or a 10-inch sewer laid within a 36-inch storm water sewer. A short distance away from the institution buildings the domestic sewer leaves the storm sewer and connects with the city's sewerage system; but the storm sewer discharges into Dry Run, which is a small, intermittent stream entering the Scioto River about a mile above the waterworks intake.

Shortly after the epidemic broke out an inspection showed that the connections between the sanitary sewer and laterals, coming from various parts of the institution, were made in at least two cases by simply discharging the laterals into the big storm sewer and constructing a bulkhead immediately below the point of discharge, through which bulkhead the open end of the main sanitary sewer projected. Under these conditions, with every storm, the water collected by the storm sewer carried the accumulated filth from behind these bulkheads into Dry Run and thence to the river. Moreover, one of the bulkheads was found to be broken, permitting some of the sewage to flow continuously into Dry Run. It was necessary to take twenty-two and a half tons of putrefying sludge out of the storm water sewer in order to clean it.

Twelve cases of typhoid fever had occurred at the institution

one year previous to the epidemic, since which time there were no reported cases until January 3, 1904. The case reported on this date was soon followed by seven more, two of which died.

Typhoid fever had occurred to a greater or less extent at Kenton, the Girls' Industrial Home, near Delaware, and at Arlington, all having sewers discharging into the river or its tributaries, and possibly at the Stone Quarries, a small settlement of unsanitary character three miles above the intake of the Columbus water works.

There is no doubt that the Insane Hospital discharged the greatest amount of sewage into the river with the exception of the cities of Kenton and Marion. Therefore, considering this as well as the proximity of the institution to the water-works intake (one and one-half miles following Dry Run and the river), the extremely low stage of the river at this time, and the fact that there was typhoid fever at the institution at least ten days previous to the beginning of the rapid increase in the cases in Columbus, it seems fair to conclude that the principal factor in causing the epidemic, if not the sole cause, was the State Hospital.

It is to the credit of the citizens of Columbus that, realizing through this epidemic the importance of pure water, they voted last fall a bond issue of $1 200 000 for improving and filtering the water supply. A filtration plant will soon be built.

THE MISSISSIPPI RIVER AS THE SOURCE OF WATER SUPPLY FOR THE INHABITANTS OF THE MISSISSIPPI VALLEY.*

BY ERASTUS G. SMITH, PH.D., PROFESSOR OF CHEMISTRY, BELOIT COLLEGE, BELOIT, WIS.

[*Read March 8, 1905.*]

Gentlemen of the New England Water Works Association, — I am very glad to be here this afternoon to say something on the subject of the Mississippi River as the source of water supply for the inhabitants of the Mississippi Valley, a matter of considerable interest to the country at large, and especially to us in the West. The subject is so large and elastic that it might be made to cover any length of time, but the limited period at my disposal naturally forbids an extended study of the whole drainage area of the Mississippi basin. This area includes the territory between the Alleghany and Rocky mountains, the upper boundary of the United States and the Gulf, a field of study which you may well judge is too broad to be covered adequately within the limits of this discussion.

Note on a map the Mississippi River in its general course, and the Missouri, the Ohio, and the Illinois rivers. Observe the location of the cities of Minneapolis and St. Paul; further down, the cities of Dubuque, Davenport, Moline, Rock Island, Quincy, Burlington, and St. Louis; and finally New Orleans near the mouth of the river.

We are accustomed to speak of the "eastern slope" of the United States, the "western slope," and the "Mississippi basin." You will note that this basin is naturally divided into several districts, representing the drainage areas of the principal tributary rivers. But to-day I propose merely to speak of the drainage basin of the Mississippi River proper, simply alluding in passing

* This address was illustrated with about seventy lantern slides, to which constant reference was made.

to these other large streams as they modify and affect the general character of the Mississippi River below the points where they join it.

There are certain contributory influences determining the various types of water carried which are quite important for us to understand thoroughly in this study of the Mississippi River. First, the drainage basin, extending over so great an area as it does, naturally would be subject to marked meteorological changes; the storms and the widely varying atmospheric conditions of the sections seriously affect the river. It is astonishing how markedly the waters of the Mississippi River, even in its upper portion, and still more so in the lower reaches, are affected by the sudden changes due to storms during the summer season. At Burlington, Iowa, for example, last year, the quality of the water would materially change overnight, the water on one day containing comparatively little suspended matter, and the next day being fairly thick and muddy from the amount of clay and silt which had been washed into the river during the night, owing to a storm which had arisen. Of course a part of this remains suspended and a part rapidly settles to the bottom of the river. Local floods thus caused and the fluctuations due to violent storms, charging the waters with suspended matter and, especially if the storms are prolonged, changing the relative amounts of dissolved matters and the alkalinity of the waters, — upon a knowledge of which the successful operation of purification works depends, — present most serious problems for the engineer to overcome successfully. In the same manner meteorological conditions affect the basins of the tributary streams, and hence more or less directly affect the main river.

A second element affecting to the condition of the Mississippi River is the *seasonal fluctuation*. This is a very important factor and one which has been too often lost sight of by those called upon to study the Mississippi River and to determine the most efficient method of the purification of its water. The water of the Mississippi River in the winter differs entirely from its condition in the spring, and especially in the months of May and June, when the waters are heavily laden with silt. It is also entirely different from its condition in August and September.

Curiously enough the river water during the early fall is often in its worst condition to purify properly. I do not know the exact reason for this, but it is associated with the low condition of the water affecting the upper drainage areas, and, probably, especially with the peculiar condition of the organic materials the waters carry.

A third influence seriously affecting the Mississippi River is the wide territory which it covers, and notably the great variety of geological formations the river traverses. The various branches of the river also traverse different geological horizons, and the materials added to the river from these exposures of different layers and horizons of rock seriously affect and modify the quality of the river water, and determine the diversity of problems of the sanitary engineer investigating the best method of treatment of the water.

If you will consider for a moment the character of these rocks of the various geological periods cut by the river, you will understand how they affect the quality of the river water. You know that granite is not soluble in water, and therefore the waters which fall on the territory where granite rocks are exposed do not become impregnated with mineral salts, but, draining off into the lake at the north and the Mississippi River to the west, they yield water of excellent quality, soft and quite free from mineral salts. The Silurian exposures which contain horizons of sandstone and limestone, and the Devonian, another area of limestone, give solutions of calcium and magnesium salts; the carboniferous exposure contributes in its own way solutions of lime and other salts; and thus the quality of the water, as we pass down the river, is materially changed. The whole territory to the northwest through the Dakotas is essentially a cretaceous deposit, so that the waters from the Missouri River are quite hard in character, and especially affect the lower ranges of the Mississippi.

Another interesting fact, which does not, however, appear from the map, is that the territory contiguous to the upper Mississippi River as far south as the upper tiers of counties of Iowa and Illinois is covered with a calcareous gravel, deposits from the great Ice Age, and varying in thickness from a few feet to some hundreds of feet at particular points. The waters from the sur-

face filtering down through this calcareous gravel take up part of the lime and magnesium salts, and thus are much increased in hardness. These calcareous gravels affect both the river waters and surface wells through the West, though not affecting the waters equally in this section of the country.

A fourth factor influencing the quality of the water is the content of the influent streams along the river. We have not time to go into the question in much detail, nor it is germane to this discussion, but water-works systems located at different points along the river are often materially affected by the inflow from small streams. The particular case of Burlington already cited was due, not to a storm distributed along any considerable territory adjacent to the main body of the river, but to a storm purely local in character, which had affected a small influent stream finding its way into the main river three or four miles above the water works. I have seen the works at Davenport, for instance, operating well one day, and the next day the waters were fairly turbid from a storm which had vented itself upon a small stream emptying into the Mississippi River a few miles above. Thus the character of the influent streams, both large and small, is a very important factor in the study of the waters of the Mississippi River. These matters may not particularly interest you gentlemen here, who have to study streams of comparatively moderate length, but they are very important elements in the varied problems presented to engineers investigating our western supplies, because, while here you have to deal with comparatively short rivers, there we have to deal with rivers hundreds of miles in length, extending over wide territory, the character of the material changing in a few miles or a few hundred miles, and those materials being transported down the stream to the purification works below.

With this brief glance at some of the more important influences at work, let us consider for a moment the general appearance of the Mississippi River. The river itself is a broad, commanding stream, through both its upper and lower reaches; having no very decided falls, the river is navigable a great part of the open season as far north as St. Paul. The banks for the most part are high and precipitous upon either side.

What results do these agencies and others — and there are many of them — work in this stream? The first result is a condition, not exactly peculiar to the Mississippi River, but common to many of our northern rivers in the West, namely, the presence of large amounts of extractive material which comes from the lumber lands and from the great swamps lying to the north. The logs and lumber floating or rafted down the river as already mentioned, also impart large amounts of the extractive matter. The first quality imparted is the high color, which runs frequently at ordinary stages of the river as high as 40 on the scale with which waters are usually graded. Another peculiarity of this extractive matter in the Mississippi River is its rather acid character. I take it that this extractive matter coming down from these pine and hemlock and tamarack swamps to the north is largely material closely allied to the tannic acids, soluble in the water, as when it is studied it exhibits the characteristics of material directly taken from the barks. The nature of this material held in solution would be an extremely interesting question to investigate in detail, but we can merely allude to it in passing. This dissolved extractive matter is a gummy-like or albuminous material of a colloidal nature, which, held in suspension or in solution in the water, exhibits peculiar properties, especially when it is brought into contact with other colloidal solutions. As I shall develop later in connection with the ordinary processes of mechanical filtration by which alone this water can be successfully treated and purified, the exact nature of the dissolved material demands more thorough study than has yet been given it, as upon the correct understanding of it the intelligent application of all purification processes depends.

It should be noted in this connection that this extractive matter is extremely difficult to remove. There is need to emphasize this, because if any of you become interested in problems of this kind, or have to do with them, you will find that the removal of this matter presents the most serious difficulties. Alum seems to remove it most easily of anything. The compounds of iron, which have been recommended in later years, apparently do not materially affect this extractive matter of the upper Mississippi, and simple sand filtration hardly lowers the color of the river water.

The second result of the agencies at work on the Mississippi River water is the silt, one of the most interesting features of water purification in the West. In the East the rivers are clear as compared with the Mississippi River or the Ohio or the Missouri. To give you some idea of the amount of silt which is carried down by the Mississippi River, we have a résumé in tabular form of some of the results obtained by Humphreys and Abbott for the United States Survey in 1861. The mineral matter is present in the river in three forms: it may be in solution, or in suspension, that is, held in an exceedingly finely divided condition, or it may be as a coarser sand or gravel rolled along the bottom of the river. The amount of material carried in solution down the Mississippi River annually is something over one hundred million tons, which would be equivalent to one foot of the entire drainage surface in twenty-five thousand years, — the whole drainage area between the Rocky Mountains and the Alleghany Mountains, — this area being about a million and a quarter square miles in extent. The amount contained in suspension, that is, the silt, amounts, according to their determination, to something over four hundred million tons annually. That would be equivalent to one foot of the entire drainage surface in six thousand years. The amount contained as sand and gravel, which is too heavy to be floated in the river, but is rolled along the bottom of the river, amounts to seven hundred and fifty million tons annually, equivalent to one foot of the drainage surface in three thousand years.

The total removal by these three agencies working together would be an amount equivalent to one foot over the entire drainage area in every two thousand years. This amount each year is equivalent to a column a mile square at its base and 268 feet high; or, to put it in a little more tangible form, would make a column about thirteen times the area of Boston Common and 268 feet in height. This gives us some idea of the tremendous amount of material carried down the river annually. Of course these materials in suspension and solution, and the larger particles rolled along the bottom, present a very serious problem to the engineer when called upon to devise a system of purification for this river water.

Something should be said further regarding the sanitary signi-

ficance of this silt, because it is a factor of the problem too often disregarded. The silt contained in the Mississippi River is at once the burden of the engineer and at the same time the great means of self-purification of the river water. May I use a homely illustration? You have all taken a stone or a small snowball and rolled it along through the snow, and you know how the particles of snow tend to ball together. In exactly the same way these particles of silt moving along tend to become agglutinated or to cling together, so that the particles gradually become larger; as a result the water becomes clearer, the substances in colloidal solution become partially co-precipitated, bacteria and the micro-organisms of the water also adhere, and by their specific gravity, which is 1.9, that is about twice that of water, the particles gradually sink to the bottom. That, in itself, is a great agency for the auto-purification of our western streams. We heard a great deal about silt purification in the Chicago Drainage Canal case, and what it contributed, if anything, to the self-purification of the Illinois River. We hear of it continually in the study of the removal of materials from the river. Mr. R. S. Weston, in the admirable line of experimentation which he carried on for the proposed new works for New Orleans, showed the remarkable removal of bacteria in the lower reaches of the river due to the processes of sedimentation, increased and made more certain through the silt contained by the river water.

Another result from the agencies at work contributing to the pollution of the river, is the material carried in solution. I will simply note the fact that the waters of the river vary in mineral content, being mostly the carbonate of lime and magnesian salts in solution, and increase in hardness as samples are taken down the stream. This is of special interest, however, from the industrial standpoint, as it affects the use of water for boilers and manufacturing purposes, and I will not take your time to discuss it further now.

The fourth and the last result which I want to speak of to-day, and which I shall endeavor to emphasize again, is the contribution man himself makes to the pollution of a river water which was originally pure and clear along its upper reaches. If you examine the water front at St. Paul, Minn., you can see the sewers opening

into the river along the whole water front; had we a view of the water front of the city of Minneapolis you would find the sewers from that city emptying into the Mississippi, and could we follow the whole length of the river we would find that the waste and refuse and sewage of the cities is thrown out into the river, transforming it in reality into a great open sewer. And it is not only the sewage from the closets and the drains of the cities and the general waste and wash of the houses which is thus disposed of, for could we go down the Mississippi River at about this time of the year, before the break-up of the ice, we would find in front of any city, and especially somewhat below the city, heaps of ashes, waste, filth, dirt, night-soil, and dead animals thrown out upon the ice, there to remain only until the break-up comes in the spring, when the whole winter's accumulation is dumped into the river to be swept a little further down the stream to waste and decay along the bed of the river! What shall be said in extenuation of the action of municipalities in pursuing such a course and willfully polluting the water of the river below, which, as we shall see, is absolutely necessary for the water supply for this great territory?

With this understanding of the natural conditions controlling the influent waters, and the four chief agencies at work seriously controlling its quality, I want to speak of the water as it is actually used as a water supply. The attentive student of the water problem becomes more and more convinced that from the contour of the country, the nature of the soils, the rock exposure, the hard waters from the subsoil, from the conditions surrounding the cities ranged along the banks of the Mississippi, the people by necessity are practically driven to the river as the best and sometimes the only source of a public water supply.

At present there are in general four ways in which the water is taken and used for a public supply.

1. The first of them is that in use in Minneapolis, Minn., which, so far as I could recall in the preparation of this paper, is the only city taking its supply directly from the river and pumping the water, without any attempt at treatment, directly to the people. But that might not be so bad if Minneapolis would be reasonable

and take the water wholly above the city, — the country above the city being open, with no considerable pollution. The water, it is true, has a very high color because of the extractive matter already spoken of, but the river is not subject to polluting agencies, notably from the sewers and the manufacturing waste and débris from any great population.

In 1896 I was invited by Mr. Cappelen, at that time city engineer, to make a report upon the water supply of the city of Minneapolis. On investigating the situation I found the water above the city highly colored, charged with extractive matter, and in the report I recommended filtration of the water by mechanical filtration as the most efficient method of purification. The subject has been more fully investigated by engineers since that time, and I believe the reports have practically been unanimous in advising the filtration of the supply. But those suggestions have not been heeded, and what has been the result? There are now four pumping stations for the city of Minneapolis, one located near the center of the water front, another at a point just above the St. Anthony's Falls, both of these being in a part of the city below the out-fall of the sewers and notably below the discharge from Bass's Creek, which receives the discharge from sewers, so that the sewage from the city finds its way down the river to these intakes. The other pumping stations are located above the city, one on one bank of the river and the other (Station 4) on the other bank, having been erected since I was there in 1896. December 30, 1903, it was necessary, owing to lack of pressure, to start the pumps at Pumping Station No. 2. Immediately a typhoid fever outbreak occurred in the city of Minneapolis, of which you have been advised, as you have read engineering literature; and where were the cases located? They were located almost wholly in the section of the city taking its water supply solely from the station No. 2 above St. Anthony's Falls, the rest of the city being practically free from the disease. That was the penalty, or rather one of the penalties, which the city of Minneapolis has paid for not properly filtering or purifying the water of the river in some way.

2. A second method of treatment is the very simple one of simple sedimentation of the water, pumping it to a reservoir,

allowing it to stand for a period to allow the heavier particles time to separate out, and then drawing off water from the surface as the supply for the people. But, after all, there is nothing new about the purification of water in this manner. Many of you have been in Rome and have seen those great aqueducts stalking across the Campagna, by which the old Roman engineers brought water practically on a level from the base of the Apennines. Sometimes there were two, and even three, of these aqueducts, one above the other as they were forced still farther back after the water, bringing it in on a yet higher level. But what interests us most to-day is the fact that the old Romans had an idea of the purification of water, and that there is nothing new after all in the process of sedimentation. There were sometimes breaks in the old Roman aqueduct, in order to introduce a set of sedimentation chambers, remains of which have been found. There was the in-flow of the water from the aqueduct into one chamber, thence down into a second, thence into a third, then up into a fourth chamber, and so on out into the aqueduct again. What was the result? It simply stayed the force of the stream, allowing a chance for sedimentation, so that the sand and gravel as it rolled along upon the bottom of the aqueducts could settle down in these several chambers. Whenever necessary the current could be turned off and these chambers cleaned out.

As an example of modern sedimentation works, perhaps the most satisfactory in this country, and in constant use as long as any, I would cite those at Omaha, Neb., which deal with the waters of the Missouri River. The Missouri River is much more heavily laden with silt than the Mississippi, the water being of a muddy appearance through the greater portion of the year — its Indian name signifies "The Big Muddy." It is plain that this silt must be removed from the water before it is used. At Omaha the water is pumped up from the river into the upper basin, whence it flows over a low dam into a lower one and then into the third. I have seen the basins cleaned after a few weeks' use during the floods in the springtime when the waters were heavily charged with silt, and as much as sixteen feet of silt in one of these upper basins, an amount about one foot in depth at the same time being deposited in the second basin.

The process of sedimentation is used very largely upon the Mississippi River at the present time. At the filtration works at Davenport, Ia., a most efficiently operated works on the Mississippi River, it was found necessary to introduce a system of pre-sedimentation, particularly to get rid of the great body of silt brought down by the river, thus relieving the filters of a great deal of work which they otherwise would have to do. The settling basin is of heavy concrete construction, of a capacity of 5 000 000 gallons, allowing the water a full twenty-four hours' sedimentation. The water is pumped by a low-pressure pump, through a main reaching to the upper end of the basin; it is then skimmed off through a weir at the opposite end into the fore-bay where it is mixed with alum and after sedimentation and coagulation is delivered to the pumps for filtration. The cleaning is done by a water main which is laid on the floor of the basin, near the long side walls; jets of water issuing under pressure drive against the walls, and as the water flows back along the floor of the basin, men with shovers push the silt and coarser sand into a central gutter, through which it runs off to the sewer, discharging into the river below the intake, this being a very cheap and economical method of cleaning the settling basin.

Further down is the largest sedimentation system on the river, namely, that at St. Louis. The water works of St. Louis to-day are located at the Chain of Rocks above the city. It should be said in passing that the water is now treated with iron and lime, facilitating the rate of sedimentation; but at present few definite data are available upon the process, which is simply one of sedimentation.

The following interesting table is taken from the report of Mr. Flad to the city of St. Louis in 1900, and gives some idea of the immense amount of silt removed from the settling basins:

DEPTH OF SILT IN INCHES IN EACH BASIN. — ST. LOUIS WATER WORKS.

1899	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		Cost.
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	
May	23	18	24	19									$955.97
June	23				32	28	33	29	36	30			1 293.99
July	24	18	20	14	19	14	17	12			39	34	857.57
September									14	10	17	12	174.50
October	24	19	22	17	22	17	17	12					433.87
Total	71	55	66	50	73	59	67	53	50	40	56	46	$3 715.90

NOTE. — Columns "a" show total sediment deposited; columns "b" show the sediment removed by manual labor.

The total amount of sediment deposited in the basins during the year was 317 000 cubic yards, of which 248 000 cubic yards was removed by manual labor, at a cost of $3 715.90, or 1.49 cents per cubic yard.

3. The third method of purification, namely, that of slow sand filtration, requires but brief consideration in this connection. We of New England are very apt to think of the purification of water by slow sand filtration as the best method of purification, and it is undoubtedly the best system with a moderately colored water, and where the suspended materials are low. But from what has been said you can understand why it is not readily applicable to the Mississippi River. In the first place, slow sand filtration does not materially remove color due to dissolved materials. In the second place, by that method you cannot filter a water so heavily charged with silt as this water. This is one of the reasons why the filters at Rock Island failed in 1900, at the time of the terrible outbreak of typhoid fever in that city. It has, therefore, been necessary to recommend some modified system with previous treatment in some form, as was done by Mr. Hazen at St. Louis, and by Mr. Weston at New Orleans, to prepare the water for the filtration by the slow sand process.

Slow sand filters, I want to say, are nothing new. They have been abundantly successful in Europe, and in this country where the water to be filtered was adapted to them, but they have thus far been inoperative upon the Mississippi River, for reasons I have

endeavored to make clear, and hence it is unnecessary for me to dwell longer upon them.

4. The fourth and last method, which has found extended and successful application upon the Mississippi River, is that of mechanical filtration. It is unnecessary to enter in any detail into the subject of mechanical filtration with this audience, as you are all undoubtedly familiar in a general way with its principles. Mechanical filtration is applicable to almost any natural water provided that water carries in solution certain amounts of dissolved salts. It depends primarily upon the presence of dissolved alkali in the natural water which can react upon materials added during the process. With the waters of the Mississippi Valley the alkali most commonly present is lime or magnesia, and the substance most commonly added is alum, or, more properly, aluminium sulphate, which in contact with the alkali contained in the water unites with it and forms an insoluble compound, aluminium hydroxide, which in turn acts upon the silt and other materials contained in the water so that they can be removed. The following alternate chemical equations express something of what happens.

$$Al_2(SO_4)3 + 3\,H_2Ca(CO_3)_2 = 2\,Al(OH)_3 + 3\,CaSO_4 + 6\,CO_2$$
$$\text{(Mg)} \qquad\qquad\qquad\qquad\qquad\qquad \text{(Mg)}$$
$$\text{(2 Na)} \qquad\qquad\qquad\qquad\qquad\qquad \text{(2 Na)}$$

$$Al_2(SO_4)_3 + 3\,CaCO_3 + 3\,H_2O(+XCO_2) =$$
$$\text{(Mg)}$$
$$\text{(2 Na)}$$

$$2\,Al(OH)_3 + 3\,CaSO_4 + 3\,CO_2(+XCO_2)$$
$$\text{(Mg)}$$
$$\text{(2 Na)}$$

By the chemical reaction of the alkali dissolved in the water and the added alum, aluminium hydroxide is formed, and this being insoluble in water serves to entangle and ball together in a mechanical fashion, or as we say, "coagulate," these particles of silt. A point for future investigation is that this aluminium hydroxide separates out in what is known as the colloidal condition, which appears to exert a remarkable influence upon microorganisms and the bacteria contained in the water, fixing and removing them with the silt and other suspended matters. This is particularly true of certain other metals, and will be the subject

of interesting future study by those who have to do with the purification of our water supplies.

The amount of alum which must be added to give maximum efficiency of purification is a matter purely of experiment, at particular points where plants are to be installed. It is necessary only to refer to the brilliant experimental work done in these later years by Mr. E. B. Weston at Providence, Mr. George W. Fuller at Louisville, Mr. Allen Hazen at Pittsburg, and by Mr. Robert S. Weston at New Orleans upon the problem of the amount of material which shall be added in order to purify the river water, to indicate the extent to which such investigations must be carried.

The problem of properly purifying the water of the Mississippi River, of such high color and heavy burden of silt, contaminated also with industrial waste and municipal sewage, is a most complicated one. Where demand for purification of the water has arisen, it has been met most satisfactorily thus far, by the installation of plants of the mechanical type. At present there are at least ten important points on the river where the waters are thus filtered and purified. The plants differ somewhat in construction and efficiency, but in the main the general type of construction is the same. At some plants the filters are of the gravity type; at others, of the pressure type; while at Moline, the most recent plant installed upon the river, the construction is of solid concrete masonry throughout.

The filter plant at Davenport Ia., is the one with which I am most familiar. The plant is of the type known as pressure filters, and consists of ten cylinders, resembling large boilers, each cylinder divided into three compartments. In each compartment there is placed about sixty inches of sand, the sand used being that from near Red Wing, Minn. As you will note, the sand is washed by a current of water issuing from the set of arms, which can be raised and lowered through the sand bed by hydraulic pressure. During the process of washing, the materials which have accumulated upon the surface of the sand bed, or have penetrated more deeply into the bed itself, are carried away by the constant stream of water through the sewer pipes, discharging into the river below the intake.

Alum is used as a coagulant, it having been found to be the most satisfactory material to use with the rather high color content of the river water at this point.

It is interesting to note the difference in bacterial content between the water taken from the channel of the river and water taken more near shore, as is found by comparing results of the plant at Davenport and the plant at Moline, which takes its water nearer shore, a short distance above.

As compared with the best results obtained elsewhere, with mechanical filters, as at Lorain, Ohio, and Little Falls, N. J., they compare most favorably. Also the results will be found to compare most favorably with those obtained by the process of slow sand filtration, as at Ashland, Wis.; Lawrence, Mass.; Albany, N. Y.; London, England; and Altona, Germany.

The use of materials other than alum has been advocated in connection with the Mississippi River water, in particular the use of iron sulphate and lime. At Quincy, Ill., the introduction of the so-called iron-lime process has been found to be fairly satisfactory, but at Moline, Ill., during a test run covering a period of sixty days, during May and June, 1904, it was found that the process was less satisfactory than alum, especially in removal of the color of the water due to dissolved materials.

The subject of the Mississippi River as the source of water supply for the inhabitants of the Mississippi Valley was chosen for this occasion because of the tremendous significance of the water supply of the Mississippi Valley of the present and the future affecting so vitally such an immense population. If you will study the last census reports you will be astonished to find how vast a population to-day takes its water supply — being fairly forced to take it by the very nature of the adjoining country — from this great open sewer, polluted by the refuse from the cities above. A little computation will show you that above the city of St. Louis there is the waste from a population of fully a million and a half of population, that from the Missouri there is the waste of half a million population, from the Illinois River the waste from a population of two millions, from the Ohio River of a population of a million and a half, and below St. Louis a half a million, making a total of upwards of six millions at the present time whose waste

is draining into what must be the water supply for the whole lower valley.

And what of the future of this population? A very ingenious scheme is one found in the St. Louis water reports in which they have plotted out the results contained in census reports for fifty years. From the plotting you see how the city of New York is growing, how in the city of Philadelphia and the city of Chicago the population curve is rising rapidly; that of the city of St. Louis rising almost as rapidly, the city of Cincinnati on a steady increase, the city of New Orleans on a steady increase. Gentlemen, what will fifty years more show in the cases of the cities of the Mississippi Valley, providing the rate of increase continues during the next fifty years as it has through the last fifty? Who can foretell how vast is the population bound to come into the Mississippi River valley, and which, if present conditions continue, will discharge its waste into the river, each city thus becoming a polluting agency to the water below?

There are at present upon the Mississippi River proper 25 public water supplies, of which number 16 are under private administration and 9 under public administration. Where water is supplied under private administration 11 supplies are filtered and 5 are unfiltered. The population supplied with filtered water under private administration is 192 000 and with unfiltered water 43 000, or a total of 235 000. Of the supplies under public administration there are only two which furnish filtered water; one of those, at Rock Island, is of questionable efficiency, and the other, at Moline, has just been installed. The population supplied with filtered water under public administration is 33 000; the population supplied with unfiltered water is 1 117 000.

In closing, I must only add that the one particular subject I wished to interest you in to-day is that of the preservation of the purity of our great natural water courses. The Mississippi River is the most striking example this country affords of the abuses to which a natural water course is subjected. Whatever force there may be to the argument for the self-purification of running streams, in the efficiency of systems of purification by sedimentation and filtration installed for the protection of the public, the fact remains that waters which from the very conditions of environment

must be taken as the normal food supply of the people should not at the same time be made the carriers of sewage and waste of a great and rapidly growing population. All principles of sanitary science are against such a course, and the esthetic nature revolts at the idea. The fullest protection to the public possible against such procedure is the problem which I want to interest you in, and in closing I wish once more to raise a protest against the present needless, not to call it criminal, proceeding of our inland American cities, whereby the waste is thrown out into the rivers to be washed down the stream, without any interposition by the state or national government to protect the lives and health of its citizens. This, gentlemen, is a problem to which water-works engineers and water-works managers, not to speak of the public at large, ought to give their time and study and their best ability.

THE PRESIDENT. We should be glad to hear further on this subject from Mr. Fuller.

MR. GEORGE W. FULLER. I wish to express my appreciation of the admirable way in which Professor Smith has set forth the general features of the problem in the Mississippi Valley. I think he has put before you its salient features, and I wish to subscribe to his closing sentiment. His statement of the case has been very clear, and I will not attempt at this late hour to go into any further details. I will merely say again that I think his view is thoroughly sound and correct, and I am happy to endorse it.

PROCEEDINGS.

March Meeting.

Hotel Brunswick,
Boston, Mass., March 8, 1905.

President George Bowers in the chair.

The following members and guests were present:

Members.

S. A. Agnew, F. E. Appleton, Edward Atkinson, C. H. Baldwin, L. M. Bancroft, F. D. Berry, J. F. Bigelow, J. M. Birmingham, George Bowers, Dexter Brackett, E. C. Brooks, G. A. P. Bucknam, James Burnie, J. C. Chase, H. W. Clark, F. C. Coffin, R. C. P. Coggeshall, M. F. Collins, W. R. Conard, B. I. Cook, J. W. Crawford, E. D. Eldredge, August Fels, C. R. Felton, F. L. Fuller, G. W. Fuller, J. C. Gilbert, A. S. Glover, F. W. Gow, R. A. Hale, J. O. Hall, J. C. Hammond, Jr., J. D. Hardy, T. G. Hazard, Jr., D. A. Heffernan, B. E. Helme, H. G. Holden, H. R. Johnson, W. S. Johnson, E. W. Kent, Willard Kent, G. A. King, L. P. Kinnicutt, J. W. Locke, E. E. Lochridge, S. H. McKenzie, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, F. E. Merrill, Leonard Metcalf, H. A. Miller, F. L. Northrop, Dwight Porter, J. B. Putnam, W. H. Richards, W. W. Robertson, A. T. Safford, E. G. Smith, J. T. Stevens, T. V. Sullivan, W. F. Sullivan, R. J. Thomas, W. H. Thomas, J. L. Tighe, D. N. Tower, W. H. Vaughn, R. S. Weston, G. E. Wilde, F. B. Wilkins, C.-E. A. Winslow, G. E. Winslow, F. E. Winsor, E. T. Wiswall, E. Worthington, Jr. — 76.

Honorary Members.

Wm. T. Sedgwick, F. W. Shepperd. — 2.

Associates.

Ashton Valve Co., by Harry H. Ashton; Harold L. Bond & Co., by Harold L. Bond; J. B. Campbell Brass Works, by W. R. Darrow; Coffin Valve Co., Co., by H. L. Weston; H. A. Desper; Wm. H. Gallison Co., by N. E. Stilphen; Wm. H. Greenwood; Hersey Mfg. Co., by Albert S. Glover, J. A. Tilden, H. D. Winton, W. A. Hersey; Kennedy Valve Co., by M. J. Brosnan; H. Mueller Mfg. Co., by W. L. Dickel; National Meter Co., by Chas. H. Baldwin, J. G. Lufkin; Perrin, Seamans & Co., by James C. Campbell; Rensselaer Mfg. Co., by F. S. Bates; A. P. Smith Mfg. Co., by F. N. Whitcomb; Sumner &

Goodwin Co., by H. A. Gorham; Union Water Meter Co., by Edward P. King, W. F. Hogan, F. L. Northrop; the Platt Iron Works Co., by F. H. Hayes. — 23.

GUESTS.

Frank L. Weaver and M. J. Dowd, water commissioners, Lowell, Mass.; Thomas Moynihan and Patrick J. B. Sullivan and M. J. Doyle, Holyoke, Mass.; C. B. Cummings, H. A. Monk, Braintree, Mass.; F. W. Dinwiddie, water registrar, Gardner, Mass.; Wm. French, Worcester, Mass.; M. O. Leighton, chief division of hydro-economics U. S. Geological Survey, Washington, D. C.; Theodore Moorehead, Chinese government service, Shanghai, China; Edw. H. Keith, mayor, Brockton, Mass. — 12.

[Names counted twice — 3.]

The following were elected to membership:

Resident. — Michael J. Doyle, Holyoke, Mass., water commissioner; W. B. Claflin, Jr., Hopkinton, Mass., water commissioner and superintendent of the Hopkinton Works; Irving S. Wood, Providence, R. I., assistant engineer in charge of water department of the city engineer's office, Providence, R. I.

Non-Resident. — H. E. Jordan, Indianapolis, Ind., bacteriologist and chemist to the Indianapolis Water Company; Marshall O. Leighton, U. S. Geological Survey, Washington, D. C.

The Secretary read the proposed change of by-laws, as follows:

That Sect. 1, Article III, be amended by the addition of the following clause: "All applications for membership presented to the Association for action must be accompanied by the proper initiation fee and dues for whole or fractional part of current year in which application is presented."

That Sect. 5, Article III, be amended to read: "The annual membership dues shall be payable in advance on the date of the Annual Meeting in January. At the expiration of ten months after the Annual Meeting, the Secretary shall notify each member who has not paid his dues for the current year, that unless the same are paid within thirty days, his membership in the Association shall cease; and if said dues are not paid within said period, the Secretary shall drop the name of said member from the membership roll. The Executive Committee may, however, at its discretion, reinstate said person on the payment of all arrears."

That Sect. 4, Article VI, be amended by the addition of the following clause: "He shall deposit all funds received in such place of deposit as may be approved by the Executive Committee. All orders for withdrawal of funds and checks for disbursements shall be signed by the Treasurer and countersigned by the President."

MR. DEXTER BRACKETT. Before a vote is taken, I should like to have some one explain the reason for the amendment to Section 1, Article III.

MR. R. C. P. COGGESHALL. In relation to that I will say that the auditing committee, Mr. Robertson and myself, when we examined the books and accounts, were impressed with the fact that quite a number of members have been elected for two years and have never paid their initiation fee or their dues. Under the by-laws of the Association that was possible, for if they did not pay, they could not be dropped until the end of two years.* Now it seemed to us that if any one thought it was worth while to become a member of this Association, it was no more than right that he should do what is required by other associations of a similar character, and that is when he presents his application for membership present his initiation fee with it.

MR. BRACKETT. I am very sorry to disagree with my friend Mr. Coggeshall, but it does not seem to me that it is necessary to require an applicant for admission to the Association to send with his application the money with which to pay his initiation fee. I am sorry to hear that any one who has been elected a member has not thought it advisable after that to pay his initiation fee, and at least one year's assessment; but I had supposed that a man was not a member until he had paid his initiation, and I should certainly be in favor, if the constitution does not so provide, of an amendment to it to that effect. The next amendment, that to Section 5, provides that a person can be dropped at the end of the year, so he wouldn't be a member any longer than that anyway; and it doesn't seem to me it is desirable to have a clause in the constitution in the form proposed. I do not think it looks well. I may be wrong about it, but that is the way I feel.

THE PRESIDENT. Will you suggest any amendment?

MR. JOHN C. CHASE. With all deference to Mr. Coggeshall, I think his view in relation to presenting the initiation fee with the application does not apply to societies of this sort, although it does apply to a very large number of other societies. I think that, as Mr. Brackett has suggested, if the constitution could be

* A person elected did not, however, become a member until he paid the fees and signed the constitution.—EDITOR.

amended so as to specify that membership should not be effective until after the initiation fee is paid, that would cure the difficulty which now seems to exist.

MR. BRACKETT. As I do not suppose this is a matter which needs to be rushed through, I would move that the matter be laid upon the table until the next meeting and possibly it can be arranged in the meantime in some different form.

MR. W. W. ROBERTSON. I should prefer that the matter be acted upon now, and either an amendment made to the amendment as proposed, or else a vote taken upon the amendment as it stands, because the next meeting is some way off, pretty well toward the beginning of another year. As members of the Auditing Committee, we took it upon ourselves to look over the membership roll, and we found such a condition existing that we thought something should be done; and although this may appear a little radical, yet at the same time I think the action is perfectly justified. If there is any way of accomplishing the desired result in a milder way I should be satisfied as one of the committee, but I think the matter should be acted upon now instead of later.

MR. J. C. HAMMOND, JR. I am in favor of the amendment as proposed by the Committee. It is no cheap thing to become a member of this Association, and I think it is well to put on the bill, "Cash on Delivery."

Mr. Brackett's motion to postpone the consideration of the amendment to Section 1, Article III, was lost.

The amendments as read were then severally adopted.

The first paper of the afternoon was by Mr. William F. Sullivan, assistant engineer, Lowell, Mass., his subject being: "Test of Large Meters and Fire Supply Devices." Mr. Edward Atkinson discussed the matter from the fire underwriters' standpoint, and further discussion was postponed until the next meeting.

Prof. Erastus G. Smith of Beloit College, Beloit, Wis., gave an address on "The Mississippi River as the Source of Water Supply for the Inhabitants of the Mississippi Valley." His remarks were illustrated by a large number of stereopticon views.

Professor Sedgwick of the Institute of Technology was on the program to speak on "The Chicago–St. Louis Drainage Canal

Case," and Mr. C.-E. A. Winslow, instructor in sanitary bacteriology at the Institute of Technology, it had been announced, would describe "A Visit to Some Interesting Municipal Water Filters now under Construction." Owing to the lateness of the hour, they asked, through the President, to be excused, and they will present their papers at the first meeting in November.

The report of the Meter Rates Committee being in order, Mr. Freeman C. Coffin, chairman of the committee, said: "It is so late now that while the committee have their report ready, it seems to me it might be wise to read it by its title, and then advance copies can be printed and sent to the members of the Association, so that they will be prepared to discuss it at the next meeting."

On motion it was so voted.

Adjourned.

MEETINGS OF THE EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association March 8, 1905, at headquarters, Tremont Temple, at 11.30 A.M.

Present: President George Bowers, and Messrs. Lewis M. Bancroft, Frank E. Merrill, Robert J. Thomas, Frederick W. Gow, Edmund W. Kent, James L. Tighe, and Willard Kent.

The following-named applications for membership were received, and it was voted to recommend the same to the Association for election to membership:

As Members. — W. B. Claflin, Jr., water commissioner and superintendent water works, Hopkinton, Mass.; Irving S. Wood, assistant engineer in charge of water department of city engineer's office, Providence, R. I.; Michael J. Doyle, water commissioner, Holyoke, Mass.; H. E. Jordan, chemist and bacteriologist, water company, Indianapolis, Ind.; Marshall O. Leighton, chief division of hydro-economics, U. S. Geological Survey, Washington, D. C.

Mr. Kent, for the Committee on Treasurer's Bond, reported that the Treasurer has presented a guarantee bond of the Fidelity Trust and Deposit Company of Maryland for five thousand dollars, whereupon it was voted: That said bond be accepted and filed with the Secretary.

Voted: That the People's Institution for Savings of Worcester, Mass., the Mechanics' Savings Bank of Reading, Mass., and the First National Bank of Reading, Mass., be approved as places of deposit for the funds of the New England Water Works Association.

Voted: That George H. Snell, Frank E. Merrill, and Willard Kent be a committee to make arrangements for the June meeting of the Association.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association May 17, 1905, at headquarters, Tremont Temple, Boston.

Present: President George Bowers, Frank A. Andrews, Frederick W. Gow, Edmund W. Kent, James L. Tighe, Robert J. Thomas, Willard Kent, Lewis M. Bancroft, Charles W. Sherman, George A. Stacy, Frank E. Merrill, and George H. Snell.

Six applications for membership were received and approved, *viz.*, James M. Caird, 271 River Street, Troy, N. Y.; Wallace Greenalch, superintendent Bureau of Water, Albany, N. Y.; Theodore A. Leisen, chief engineer Water Department, Wilmington, Del.; William W. Locke, sanitary inspector, Metropolitan Water and Sewerage Board, South Framingham, Mass.; Charles H. Campbell, superintendent Water Works, Charlotte, N. C.; Luis Matamoros, municipal engineer, San Jose, Costa Rica, Central America.

Mr. George H. Snell, water commissioner of Attleboro, extended an invitation to the Association to visit Attleboro for the June outing, to inspect the reinforced concrete standpipe now in process of construction.

On motion of Mr. Stacy, it was voted: That Mr. Snell's invitation be accepted.

The subject of headquarters was introduced and after discussion it was voted: That the President, Editor, and Secretary be a committee to consider the subject of lease of rooms and to report to the Executive Committee.

The subject of annual convention was then considered. A letter from Mr. Hazen, secretary of the committee to make arrangements for same, was received and read, and Mr. Thomas, of the committee, made an interesting report of the progress of arrangements.

Mr. Merrill, Committee on Transportation, reported arrangement of fare and one-third rates for excursion to New York via Hoosac Tunnel and Hudson River, or via Fall River.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

BOOK NOTICE.

"Cement and Concrete." By Louis Carlton Sabin, B.S., C.E., Assistant Engineer, Engineer Dept., U. S. Army, M. Am. Soc. C. E. Cloth, 6 x 9¼ in., pp. 507 (incl. 11 pp. of Index), 161 tables. McGraw Publishing Company, New York. Price, $5.00.

In his preface, the author says, "The original investigations forming the basis of the work were made in connection with the construction of the Poe Lock at St. Mary's Falls Canal, Michigan." "When not otherwise stated, the tables in the work are condensed from the results of the above-mentioned investigations. In supplementing the original matter much use has been made of the experiments of others."

Part I contains two brief chapters defining the various kinds of cement and briefly describing the methods of manufacture. Part II, "Properties of Cement and Methods of Testing," contains 122 pages. Only 5 pages are devoted to "Composition and Analysis," and no methods of making analysis are given. The physical tests are discussed in considerable detail, but the details of manipulation of the tests are not given. Part III, "The Preparation and Properties of Mortar and Concrete," contains 186 pages, and is certainly one of the best available treatises on this subject. Some data of actual cost of concrete of various proportions are given, and the effects of age, of regaging, of frost, and of the admixture of various substances are discussed in considerable detail. 142 pages are devoted to Part IV, "Uses of Mortar and Concrete," including a brief chapter on reinforced concrete. Considering its importance, the subject of Forms receives very brief treatment. Most or all of the uses of concrete are described in more or less detail and generally with figures of cost of work actually constructed.

As a whole, this book is very satisfactory, and it will unquestionably take place as a standard treatise on the subject.